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CANYONLANDS NATIONAL PARK

LATHROP CANYON

ABANDONED URANIUM MINE CLOSURES

EVALUATION AND RECOMMENDATIONS

DECEMBER 22, 1988

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
LAND RESOURCES DIVISION
MINING AND MINERALS BRANCH

CANYONLANDS NATIONAL PARK

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National Park Service

Mining and Minerals Branch

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CONTENTS

Lathrop Canyon - scenic shot. The mines are located in the canyon to the right of the tall butte. The tall butte and vertical cliffs behind it are Wingate Formation, while the underlying strata are Chinle.

CANYONLANDS NATIONAL PARK

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EVALUATION AND RECOMMENDATIONS

EXECUTIVE SUMMARY

In the late 1950's, eight adits were excavated at Lathrop Canyon in search of uranium ore. The mines were connected by a service road which today is washed out and overgrown in places, and serves as a hiking trail in Canyonlands National Park (CANY). In August, 1988, at the request of the park and Rocky Mountain Regional Director, the Mining and Minerals Branch (MMB) took data to characterize the abandoned mines and quantitatively assess the hazards they present to park visitors and the surrounding environment. Our examination reveals that the park and region's concern is justified: the area is a health and safety hazard, primarily due to radioactive emissions in and around the mines. We recommend that remedial actions be taken as soon as possible. Specifically, we suggest that the mines be closed from public entry and that the area be posted for "NO CAMPING" in addition to the general radiation and water warnings already posted. We further suggest that the remnant waste-rock piles outside the mines be left in place, and that the effluent from Mine 6 be diverted with a French drain system. Several mine closure alternatives are reviewed. We feel that cable net closures are the best solution on the basis of safety, economy, and minimal disturbance to the area. An estimate for this alternative is included in the appendix.

PHYSICAL CHARACTERIZATION

Lathrop Canyon is located in Canyonlands National Park and can be identified on the USGS 15-minute Upheaval Dome Quadrangle in Southeastern Utah. It lies in the northeastern section of "The Island in the Sky," a name given to the wedge of land created by the confluence of the Green and Colorado Rivers. The mines are located at the head of the canyon as shown in Figure 1 of Appendix 2.

The mines were not extensively developed (maximum depth of 280'), attesting to the low grade of ore in the area. All drifts (tunnels) are essentially horizontal, and no shafts (vertical openings) were found. Average drift dimensions are 6' wide by 7' high, while some chambers open to a maximum of 25' wide and 11' high (see Figures 2a - 2d, Appendix 2). As the field inspector was working alone, safety dictated that minimal time be spent in the mines. For this reason most distances were determined by pacing with an estimated accuracy of ±5%. Radon and gamma radiation readings were taken while mapping the mines.

The Lathrop Canyon Uranium Mines are located in the Chinle Formation. The Chinle dates from the geologic period known as the Triassic (190 - 225 mybp (million years before present)) and is made up of rock consisting of course sandstone, conglomerate, and limestone interbedded with vari-colored shales of red, brown, purple, gray, and green. It weathers to a talus slope under the

"Barring down" bad rock from portal of Mine 5.

Debris inside Mine 6.

more recognizable cliff-forming Wingate Formation. The Chinle Formation was stream-deposited and includes many fossil plants and animals. During the later Tertiary Period (70 mybp), ground waters deposited uranium in some of these organic remains, which accounts for the formation's economic significance in Lathrop Canyon and elsewhere.

Rock conditions in the area are generally quite stable. Several loose slabs were removed from the entries to Mines 5, 6, and 7. The east branch of Mine 4 has a slabby roof which should be approached (if at all) with extra caution. For the most part the mines have been stabilized by a process called fracture-filling, whereby the high alkali content of local groundwater fills and cements cracks in the rock.

Three of the mines are wet. Mine 3 collects runoff water. Mine 6 has a slow effluent yielding one or two gallons per minute at the time of the fieldwork (August, 1988). Mine 7 retains water, apparently from seepage deeper within the mine. The water level in Mine 7 varies as evidenced by a powdery evaporite covering the floor and lower walls in dry areas. Since the field inspector was unequipped to explore flooded portions of the mine, total mine depth was visually estimated at a minimum 240', possibly deeper. In all three mines, wet areas are particularly slick and dangerous.

Debris is a major hazard in Mine 6, and to a lesser degree in Mine 4. Two large piles of rusty scrap steel and boards with protruding nails have been shoved into Mine 6, dominating most of the floor space. Smashed steel vent line, rusty cans, and boards litter some areas of Mine 4 as well.

Explosives are also a reason for concern in the Lathrop Canyon Mines. A misfire was found in the roof of Mine 7, 65' in from the portal at the intersection of the main drift and a small cutout to the west. No blasting cap was detected. As the dynamite was tightly packed and hardened into the rock, no attempt was made to remove it. If the mine is left open, this misfire should be blasted in place by someone qualified in the use of explosives. A misfire with blasting cap protruding, thought to be in the east branch of Mine 4, was reported by Ranger Judy Cox. We were unable to find it, and the possibility that it has already been removed was mentioned by Mrs. Cox. Used blackwick (a fuse material) can be found in the waste-rock pile outside Mine 2, but is harmless.

Radiation dangers are much less obvious than the physical hazards previously mentioned, requiring sophisticated instrumentation and processes to quantify. Since the effects of radiation are usually delayed, it is possible to be harmfully radiated without any awareness at the moment of exposure. On the other extreme, a person may become unduly concerned passing through an area with abandoned uranium mines, not knowing their degree of exposure or the possible consequences. For these reasons, we sampled the soil and air in and around the mines to determine the seriousness of the situation at Lathrop Canyon. The U.S. Geological Survey (USGS) is conducting a water analysis of the area. Preliminary water data from April, 1988 is summarized in this report, while data from sampling conducted in November, 1988 is forthcoming. To better understand our data, a brief primer on radiation as it applies to abandoned mine sites is included in Appendix 1. Also included is a discussion on pertinent environmental regulations and a glossary of radiation terminology. The actual data taken from Lathrop Canyon is summarized in Appendix 2.

DATA ANALYSIS

Analysis will center on answering four basic questions:

1. Do the Lathrop Canyon Uranium Mines present significant health and safety hazards warranting closure?
2. If closure is in order, what method of closure should be employed?
3. Should the waste-rock piles be moved or are they better left alone?
4. Is water contamination a significant problem, and if so, what practical remedial measures can be taken.

We will first address radon daughter concentration in the air, which is the main source of alpha radiation (Figure 3, Appendix 2). The U.S. Environmental Protection Agency (EPA) recommends a general public limit for alpha radiation of 0.4 WLM/year (see appendix 1) which equates to 69.2 WLH (working level hours), or the equivalent of 69.2 hours exposure to a concentration of 1 WL alpha. Measured against this guideline, the worst areas tested in Lathrop Canyon are the terminus of Mine 5 (Sample 13) and the eastern extremity of Mine 4 (Sample 15), where yearly exposure limits would be reached in 1.95 and 2.07 days, respectively. These areas exceed the occupational standard that approved breathing protection should be worn in radon daughter concentrations greater than 1 WL. Accordingly, they should be shut off from public access. Notice that the data reveal a trend: readings increase with depth into the mines. This stands to reason, as the radon-contaminated air near the portals (openings) is subject to dilution by fresh air from outside. The average reading for the mines 10' inside the portal (Samples 1, 4, 7, 9, 10, 17, and 20 averaged) is 0.14 WL alpha. A person could remain in this environment 20 days before reaching the recommended limit. Alpha readings outside the mines on the waste-rock piles are below the detectable range of our equipment and are considered insignificant for our purposes. Considering the limited stay of visitors at Lathrop Canyon, radon concentrations indicate the need for closing the mines, but the closures need not be airtight.

Gamma radiation in the area is less variable than alpha. For gamma radiation, the units "R" (roentgen) and "REM" (roentgen equivalent man) can conservatively be equated. ("R" is a measurement of exposure, while "REM" measures dosage, or the amount of exposure absorbed. Absorption varies with individuals and conditions, but is typically about 80% of the exposure.) The guideline of 0.1 REM per year therefore roughly equates to 0.1 R, or 100 mR (milliroentgens). Referring again to our worst cases in Figure 4, this limit would permit habitation in Mine 5 (average gamma = 0.50 mR/hr) for 8.28 days, in Mine 3 (average gamma = 0.48 mR/hr) for 8.68 days, and in Mine 2 (gamma = 0.44 mR/hr) for 9.47 days. Average gamma readings over the waste-rock piles (0.26 mR/hr averaging Samples SS5a, SS5b, SS7a, SS7b, SS9, and SS12) limit visitation in the area to 16.34 days. Although the stated limits indicate that an individual could safely stay in the area several days, it should be pointed out that radiation exposure is more harmful when high doses are

Flash flooding directly above Mine 6 has removed vast quantities of waste rock. The remaining piles beneath Mine 7 (left) and below Mine 5 (right foreground) are reasonably stable. (Picture taken from Mine 5.)

received over short periods of time, compared to low doses spread out through time. For this reason, and in keeping with the principles of "ALARA" (the principle that radiation exposure should be kept as low as reasonably achievable) and "justifiable" exposure discussed in Appendix 1, we recommend, on the basis of gamma exposure, that the mines be closed from public entry and the area be posted for no overnight camping.

We must then address whether or not the waste piles should be moved. Figure 4 gives rough estimates of total mine and waste-rock volume. The data indicate that there is more than adequate space to backfill the mines with waste rock if necessary. Figures 5a and 5b show results of assays performed on waste rock and sediments through the area. It is interesting to note from Figure 5b that uranium and radium in these areas are not in equilibrium. We surmise that this is due to selective leaching of the uranium, which is more soluble in water than radium. Relative to radium concentrations, therefore, the upper portions of the waste-rock piles are uranium-poor. Sample 5, however, suggests that the dissolved uranium is precipitated out and concentrated at the base of the pile. The data is insufficient to determine whether radioactive constituents increase or decrease with depth in the pile.

When comparing our data with standards for mill tailings disposal, our analysis should center on radium-226. Comparing our values to the standard of 5 pCi/g, we see that only the pile below Mine 8 and sediments in the local drainages come close to compliance. Our worst case, the waste pile below Mine 1, exceeds the standard by a factor of 28. This data was reviewed with the Radiation Program Branch of the Environmental Protection Agency (EPA). We recommend, with the approval of the EPA, that the piles be left in place. This recommendation is made for the following reasons:

1. If the area were posted with signs prohibiting camping, the total visitor and staff gamma exposures would be insignificant compared to doses received by workers attempting to remedy the situation by backfilling the mines.

2. Any further contamination to the environment will be minor if the piles are left alone. Mass wasting (e.g., by flash floods) has long since removed the more exposed portions of the piles. Established drainages in the area bypass the remnant piles, so deposition of vast quantities of the remaining contaminated waste material further downstream is not likely.

3. Disturbance of these stable piles would increase contamination of the environment in the form of radioactive dust and fluvial sedimentation.

4. Moving the piles would most likely require heavy equipment which would significantly scar the land. Revegetation in this desert environment would be very slow. It has been suggested that the state of Utah could use prison labor to move the waste rock by hand, but again, this would be a massive undertaking and exposure to the workers would be hard to justify when weighed against the benefits derived.

5. Waste-rock piles at abandoned mine sites are not specifically regulated by federal standards.

6. Mill tailings regulation is based on a "residential use scenario" which does not, and will not apply in a National Park setting. (It would be wise, however, not to build any park structures on or near uranium mine wastes.)

7. Backfilling the mines would be difficult and prohibitively expensive since the piles lie on steep slopes below the mines.

We therefore recommend that the waste-rock piles be left alone, and that "NO CAMPING" signs be posted. If the decision to backfill is made, reclamation should take place during a wetter time of year to minimize dust, and the rutting season for bighorn sheep in the area should be avoided.

Water analysis data provided by the USGS is summarized in Figure 6 of Appendix 2. When weighed against mine effluent standards (Appendix 1) and general EPA water standards (Appendix 3), we see that the major problem with water in Lathrop Canyon is its radioactive constituents. Arsenic is also a typical problem in the area, but the USGS apparently did not test this parameter.

The riverbed in Lathrop Canyon is typically dry. Two areas where running water reaches the surface were found and used as upstream and downstream controls. Water also drains down the bedrock exposed outside Mine 6, until it gets absorbed into the dry riverbed about 30' out from the mine. This effluent and the standing water in Mine 7 were also tested. The four sample sites are listed below:

Site 1 - upstream control, located above the area where mine drainage enters the main canyon. This site is used to establish background conditions for Lathrop Canyon.

Site 2 - effluent draining from Mine 6.

Site 3 - flooded portion of Mine 7.

Site 4 - "Sog Springs and Lathrop Canyon" - downstream control, located approximately one mile down-drainage from the mined area. This site gives an indication of the downstream effect of the mine-water contamination.

Several broad observations can be drawn from the data. Most pollutant levels are elevated at Sites 2 and 3, but drop down within acceptable limits by the time they reach Site 4. Uranium and gross beta levels are highly elevated at Site 3. Background values for gross alpha far exceed drinking water standards, while alpha values form Sites 2 and 3 are exponentially higher. (Notice that gross alpha and radium standards appear at the bottom of the water standards chart (Appendix 3) under footnote 2.) Radium levels are also highly elevated at Sites 2 and 3. Although radiological parameters are the

major concern in Lathrop Canyon water, trace metal concentrations are not to be overlooked. Most trace metals increase in downstream concentration (i.e., beryllium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, nickel, and zinc) by factors of 1.64 to 6.33 times. Barium and molybdenum remain essentially the same, while silver concentration actually decreases downstream by a factor of 2.33. Unfortunately the data is insufficient to determine if the increases are due to the abandoned uranium mines, as values for metal concentration were not given for the mine water (Samples 2 and 3). Trace metal data for sites 2 and 3 would be useful in characterizing the mine water and in determining dilution factors downstream. Hopefully this data will be provided in the future. It is important to note, however, that the downstream values for most parameters are within acceptable limits, indicating that the mines do not have a significant impact further downstream.

Since mine closures would bar people and most animals from water inside the mines, and the overall effect of the local water contamination is naturally mitigated downstream, the only significant water problem remaining is the effluent from Mine 6. This problem could be resolved in two different ways: a watertight bulkhead could be devised, or the water could be diverted to a less harmful location.

Attempting to seal off the mine could be problematic. If the seal is successful, the confined water would most likely find another way to escape, perhaps through a seam in the rock. Put simply, a watertight bulkhead does not ensure that the contaminated water will not emerge elsewhere.

Our preference is to divert the effluent to a less exposed location. A collecting pool could be constructed inside Mine 6 by building a small check dam inside the entrance. The dam could be made of concrete and reinforced with rebar embedded into the bare rock floor. It need not be very large, perhaps 18" high, requiring 6 to 10 bags of concrete which could be packed into the area and hand-mixed at the site. The top of the pool is then drained by steel pipeline to a sandy area in the drainage approximately 50' beyond the mine entrance, just beyond the point of impact from local floods (see picture adjacent page 4). The pipeline should terminate in a buried French drain system. This design would keep contaminated water buried in the streambed, inaccessible to park visitors and animals. Plants, which tend to concentrate radionuclides, could still tap the water, but there is no evidence to date of harm to animals grazing in the area. Combined with some form of mine closure, the diversion would mitigate the problem of exposed, highly contaminated water at the site. This design would also eliminate a hazard at the mine entry where the effluent causes a slick spot leading to a steep dropoff of approximately 15' elevation.

CLOSURE ALTERNATIVES

It has been adequately established that the abandoned Lathrop Canyon Uranium Mines should be closed from public access. Old campfire rings and footprints, however, indicate that the mines have been used despite signs already posted by the park, warning of elevated radiation levels and contaminated water. Alpha radiation at the extremities of the deeper mines approaches and exceeds occupational limits for entry without breathing protection. A conservative approach to gamma levels throughout the area precludes camping, which may

be more tempting inside the mines than out. The mines provide a cool retreat from the hot desert sun, and could serve as a refuge from the torrential rains which occasionally drench the area, thereby acting as an attractive nuisance to a situation more threatening than the one the park visitor was trying to escape. Explosives have been found in the area. Wet areas of the mines are very slick, and serious cuts could be received from rusty scrap steel and nails. Perhaps most importantly, an unattended, abandoned mine is not a place to treat casually. Although the rock in the area is generally stable, some loose slabs were found and rock-falls could occur. In all these examples, the Park Service assumes a degree of liability in leaving the mines open.

Assuming the need for closure, therefore, the type of closure must then be decided. There are two basic types of mine closures: permanent and temporary. Each has its advantages and disadvantages. Permanent closures are generally more secure, but they are often expensive, may be impractical in remote areas, and they destroy any cultural and historical significance the site may have (Lathrop Canyon Mines were nominated for the National Register of Historical Places in July, 1988). Temporary closures are often more economical and are better for preserving historical significance, but require constant monitoring for vandalism. Several possible closure alternatives are discussed below. These should be reviewed by the park with the state of Utah, which will act as the contracting agent for the project.

1. Signs: Signs allow visitors to make an informed choice to avoid hazardous situations, and should be included with all temporary closures. They are subject to vandalism and theft, however, and require constant monitoring and maintenance. Signs should be made of weatherproof materials, be easily replaceable, and carefully worded to inform the public without causing undue alarm. An example of a good radiation warning sign is included in Appendix 4. It is felt that, while a sign might cover the park's legal obligation, this is an insufficient measure and would not discourage more determined visitors. Once in the mine, an individual is confronted with a variety of hazards, not all of which are obvious.

2. Conventional Fence: This alternative goes a step beyond posting signs, but is still easily defeated. Fencing is a temporary measure at best, requiring frequent status checks and maintenance.

3. Backfilling: The mine entries could be backfilled with rock from the waste piles. While this would eliminate materials costs, backfilling is labor-intensive: rock would need to be transported uphill to the mines. Moreover, this option would have the maximum negative impact on the environment and workers. Heavy equipment would scar the land and radioactive dust would blanket the area. As mentioned above, backfilling by hand with state-supervised prison crews would reduce the impact on the area, but, in our opinion, would expose the workers to unreasonable levels of radiation.

4. Foam Plugs: Foam plugs can be effective in forming airtight, flexible seals. Similar to foam insulation products used in homes, foam comes in two massive canisters which are mixed under pressure and shot from a gun to totally fill a large opening. Canisters would most

likely be airlifted into the area by helicopter. Although foam plugs are installed quickly and would have little impact on the area, they have three major drawbacks:

a. Expense - The foam and the required helicopter service are relatively expensive.

b. Photosensitivity: Foam is subject to decomposition when exposed to sunlight. Once installed, the surface would need to be masked, possibly with a covering of waste rock.

c. Security: If exposed, foam could easily be cut with a knife or shovel. Having cut off airflow inside the mine, alpha radiation levels would have built up behind the bulkhead. If vandals managed to penetrate through the plug, which would not be difficult, they could be exposed to high levels of radiation. This problem could be eliminated by reinforcing the plug with rebar or chainlink fence just beneath the exposed surface.

5. Concrete Bulkheads: While concrete is certainly the most secure and permanent option, the remote location of Lathrop Canyon makes it extremely expensive. Inaccessible by concrete truck, batches of concrete would need to be airlifted to the site by helicopter, then transported to forms constructed in the mine openings. A concrete bulkhead could be used to seal the seepage from Mine 6, but, as mentioned above, a watertight bulkhead does not guarantee containment of the contaminated water.

6. Cinder Block Bulkheads: Sealing mine entries with single or double walls constructed of cinder block has been suggested as an alternative to solid concrete bulkheads. Blocks could be trucked into the area, reducing the expense of helicopter assistance required for concrete pours. While a cinder block wall may seem fairly impervious in urban settings, it is not so reliable in this application. Cinder blocks weather in exposed locations, and through the years would lose their integrity. Furthermore, they crack easily when subjected to the pressures which could be imposed by the unstable rock overlying the mine openings. Cinder block bulkheads, therefore, are temporary closures which would require constant monitoring. They are relatively expensive and labor-intensive when compared to other temporary closures.

7. Blasting: Blasting is often an effective means of permanently closing dangerous mines. While the park and state of Utah may wish to pursue this option in more detail with a blasting expert, it is felt that the Lathrop Canyon Mines do not lend themselves well to this closure alternative. Blasting closure would be complicated by the large overhangs and vertical cliff walls directly above the mine portals. Attempted blasts could easily fail, sending rock downhill rather than filling the openings. This would increase the size of openings rather than close them, thereby destabilizing the overlying rock and leaving a visible scar. The drilling required would

Typical cable-net closure at
Coranado National Memorial, Arizona.

necessitate the use of a sizeable air compressor, which adds to the cost and impact on the area. Blasting is therefore somewhat unpredictable, and often exceeds original time and cost estimates.

8. Cable Nets: The staff at Death Valley National Park (DEVA) has developed a highly successful and unique mine closure technique using nets made of ¼" stainless steel cable. Using a Punjar rock drill, these nets are securely bolted to the rock with irretrievable 3' split bolts used in the mining industry to secure loose rock. Cable nets allow mines to breathe, preventing a buildup of radiation levels behind the closure. As noted above, alpha levels at the mine openings are not of particular concern. While a cable net closure would not stop the effluent from Mine 6, the proposed French drain system could be used effectively to mitigate this hazard. If net closures are used, radiation warning signs could be posted inside the mines where they would remain visible, but less subject to vandalism and theft.

   The DEVA crew is available to install nets in Lathrop Canyon. Since their method is unique and perhaps unfamiliar to those evaluating closure alternatives, a cost estimate for the job is included in Appendix 5. This estimate was solicited by the park in June, 1988, and covers the closure of the 9 openings the park considered most dangerous.

   Although cable nets are considered temporary closures, the term "temporary" in this case should be qualified. These nets are highly resistant to weathering and vandalism, and should last 100 years or more under normal circumstances. Net installation is ideally suited to remote locations such as Lathrop Canyon, and will have minimal impact on the area. Cable nets would allow curious park visitors to see into the mines while minimizing health and safety dangers. In our opinion, DEVA nets are the best closure solution for Lathrop Canyon on grounds of economy, feasibility in a remote location, visitor protection, and minimal damage to the natural and historical resources of the area.

These options should be reviewed by the park with the state of Utah for feasibility, effectiveness, and estimated cost. MMB is available for further consultation as needed.

SUMMARY

We conclude that the Lathrop Canyon Uranium Mines present a hazard worthy of immediate attention. We recommend that the waste-rock piles be left undisturbed and that the mines be closed with Death Valley cable nets. We further recommend that the area be posted with "NO CAMPING" signs in addition to the signs already posted warning of radiation and water contamination in the area. The effluent from Mine 6 should be diverted with a French drain system. Other closure options and their costs should be reviewed with the state.

Our recommendations will reduce radiation exposures to reasonable levels and eliminate the hazard of exposed, highly contaminated water. We feel that this plan of action best preserves the balance between visitor safety and enjoyment of the park.

APPENDIX 1

RADIOACTIVITY AND ABANDONED MINERAL LANDS

APPENDIX 1

RADIOACTIVITY AND ABANDONED MINERAL LANDS

RADIOACTIVITY: A BRIEF INTRODUCTION

Radioactivity can be defined as the spontaneous release of particles and energy by the nucleus of an unstable atom. The following page shows the Uranium-238 Decay Series, where unstable uranium (U238) undergoes a systematic decay process until it reaches a stable state as lead (Pb206). Three types of radiation are emitted in this process. Alpha radiation occurs as a radioactive atom decays by releasing an alpha particle from its nucleus. An alpha particle is identical to the nucleus of a helium atom, containing two neutrons and two protons, which give it an atomic mass of 4. An atom undergoing alpha decomposition, therefore, has a corresponding drop in atomic mass and becomes a new element. Gamma rays may also be released in this process. Like light and X-rays, these are energy rays, having no mass or electrical charge. Radioactive elements may also decay into other elements of the same atomic mass by emitting a beta particle from the atomic nucleus. A beta particle is negatively charged and has the same mass as an electron. Beta radiation may also be accompanied by gamma emissions. There are other decay series similar to that of uranium-238, but the bulk of the radiation in an abandoned mine site is typically caused by the uranium series, and it is appropriate that we confine our analysis to that.

The key to an element's radiological activity is its half-life: the time required for half of the atoms of a radioactive element to decay (Figure A).

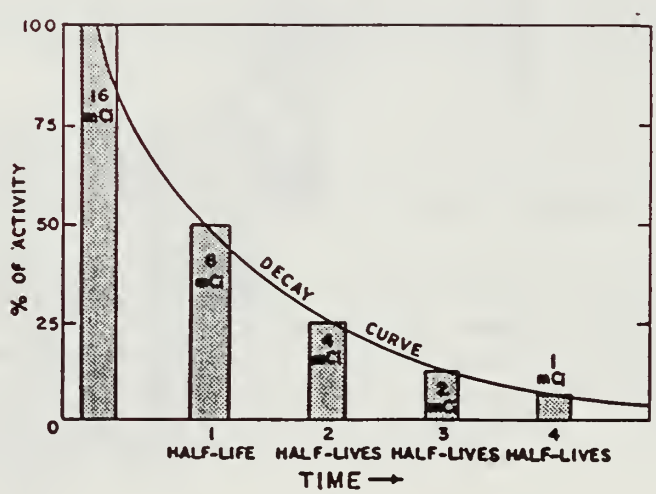
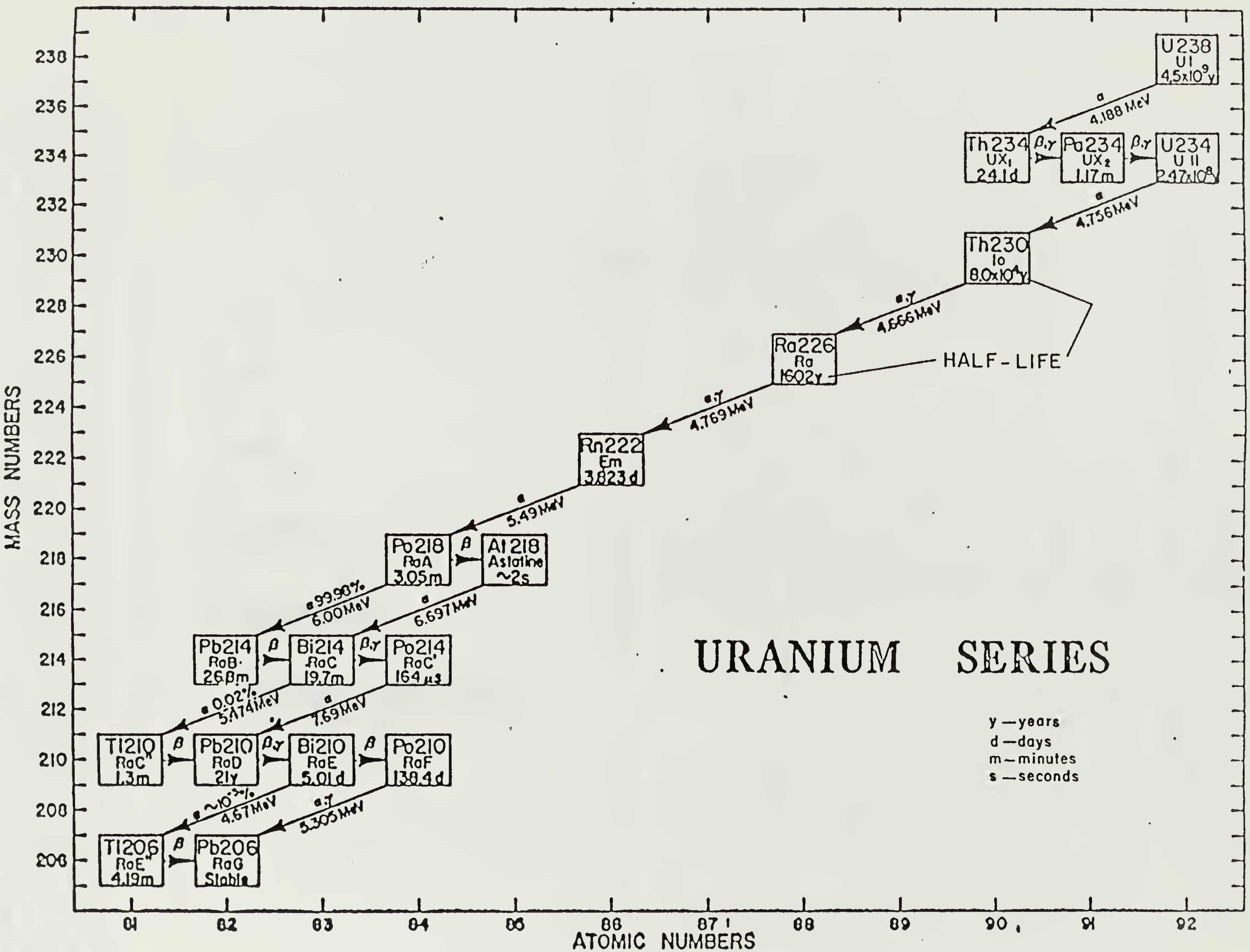


Figure A: Half-life of a radioactive element.

Note that the half-lives for most of the elements in the uranium decay series (see following page) above radium (Ra226) are quite long. On the other hand, the "progeny" of radium (those elements below Ra226 in the series) have much shorter half-lives, thereby accounting almost exclusively for the measurable radioactivity at a site such as Lathrop Canyon. Although radium itself is not


URANIUM SERIES
U238 UI 4.5x10^9 y
Th234 UX1 24.1d
Pa234 UX2 1.17m
U234 U II 2.47x10^5
Th230 Io 8.0x10^4 y
Ra226 Ra 1602y
Rn222 Em 3.823d
Po218 RaA 3.05m
At218 Astatine ~2s
Pb214 RaB 26.8m
Bi214 RaC 19.7m
Po214 RaC' 164 μs
Tl210 RaC" 1.3m
Pb210 RaD 21y
Bi210 RaE 5.01d
Po210 RaF 138.4d
Tl206 RaE" 4.19m
Pb206 RaG Stable
α 4.188 MeV
α 4.756 MeV
α,γ 4.666 MeV
α,γ 4.769 MeV
α 5.49 MeV
α 99.98% 6.00 MeV
α 6.697 MeV
α 0.02% 5.474 MeV
α 7.69 MeV
α ~10^-5% 4.67 MeV
α,γ 5.305 MeV
β,γ
β
HALF-LIFE
y—years
d—days
m—minutes
s—seconds
MASS NUMBERS
ATOMIC NUMBERS

particularly active (half-life = 1602 years), it is the direct parent of the most active constituents in the decay series. Radiological safety standards for water and soils are therefore keyed to radium due to the more active progeny it generates. Air standards are keyed directly to radiation produced by "radon daughter" concentrations. "Radon-222 daughters" are commonly considered the first four progeny of radon gas in the uranium-238 decay series, specifically, RaA (Po218), RaB (Pb214), RaC (Bi214), and RaC' (Po214). If radium could be removed from the rock and water in the area, the most active portion of the series would essentially be cut off and the radiation hazard would quickly give way to thousands of years of acceptable low level radiation. In an attempt to reestablish equilibrium (the state at which the radioactivity of consecutive elements in the decay series is neither increasing nor decreasing), the remaining thorium-230 (half-life = 80,000 years) would require years to decompose and produce substantial increases in radiation level. Radium content, therefore, is the key to radiological activity.

The potential damage caused by alpha, gamma, and beta radiation is determined by the combined effect of their penetrating power and their ability to "ionize" (alter) tissue. Figure B depicts the relative penetrating power of the three forms of radiation:

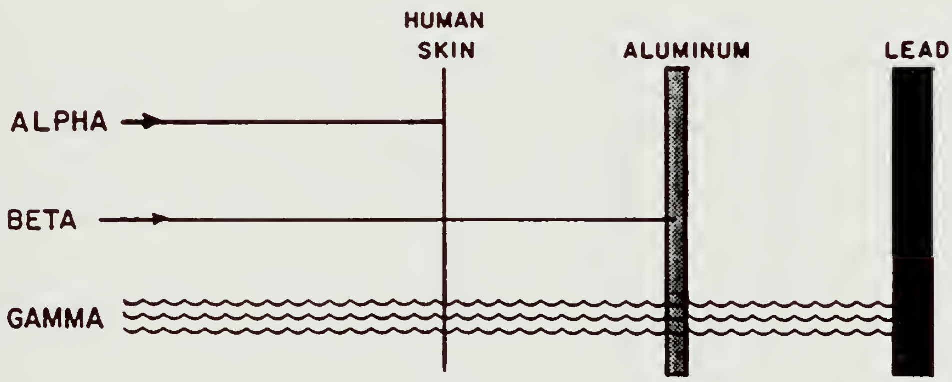


Figure B: Penetrating powers of various types of radiation.

The ability of radiation to alter molecules with which it comes into contact is termed "ionizing potential." It is important to note that the ionizing potential of alpha radiation far exceeds that of beta and gamma. This is due to the size, electrical energy, and mass of individual alpha particles. The relative ionizing potential of alpha:beta:gamma is 100,000:100:1. Figure C shows the comparative effects of the three types of radiation:

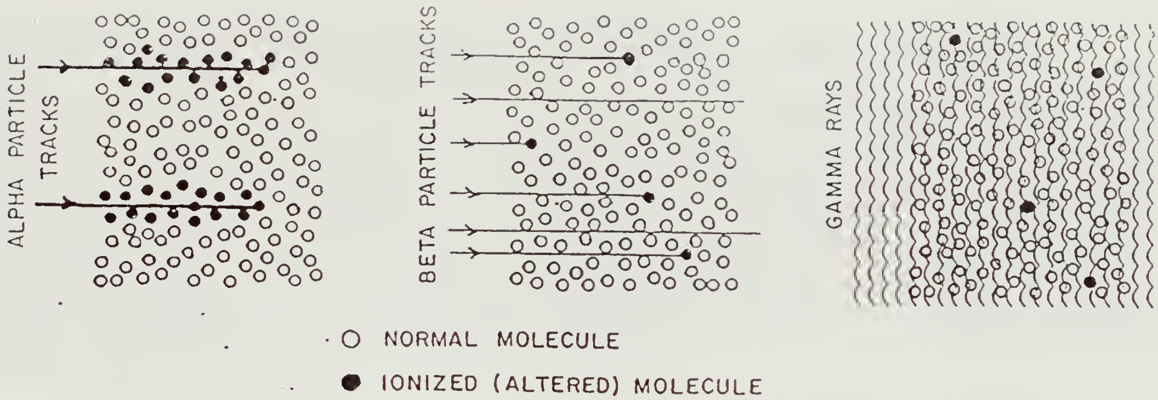


Figure C: Ionizing potentials for various types of radiation.

When the combined effect of the penetration and ionizing potentials is considered, it is found, except in extremely unusual circumstances, that alpha and gamma radiation are most dangerous to living tissue, while beta is relatively insignificant.

Alpha radiation is of primary concern when radon gas and condensation nuclei (fine dust and mists suspended in the air) with attached radon daughters are inhaled or ingested. Radon daughters have a high affinity for particulates in the air, in fact, the unattached daughters remain as free ions in the atmosphere for only 10 - 60 seconds before being "plated out" on solid surfaces. Whereas free ions are less prevalent than "attached" daughters, they are still significant, since once in the lungs, they are much more likely to be retained. Their tendency to plate out is much greater than the chance of a dust particle with an attached daughter getting trapped. Once a radioactive atom is inhaled, it, or the particle to which it is attached, may get lodged in the lungs. The lung tissue will then be affected when the atom decays. Although human skin absorbs alpha radiation and protects the tissues beneath, fragile tissues of the lung can be seriously damaged as pictured in Figure C. Specialized dust filters approved by the Mine Safety and Health Administration (MSHA) or The National Institute of Occupational Safety and Health (NIOSH) provide reasonable protection in low levels of alpha, while a supplied air device is required in more extreme conditions. Since alpha is of primary concern when taken into the body, it is generally considered an internal radiation hazard. External alpha health hazards require extremely unusual levels of radiation.

Gamma radiation, on the other hand, is the primary external radiation hazard. Alpha radiation, being airborne, is best controlled by ventilation. Stagnant air in an abandoned mine will be more highly contaminated than the air on and around the open waste-rock pile outside the mine, where fresh, uncontaminated air is constantly diluting and removing irradiated air. By contrast, gamma readings, independent of air circulation, should be fairly consistent throughout the area.

RADIOACTIVITY: ENVIRONMENTAL STANDARDS AND GUIDELINES

It should be noted that, to date, there are no approved standards regulating radioactive substances or emissions from abandoned mine sites. This does not, however, negate our concern for radiological hazards from abandoned mines in the park system. If park staff and visitors can be significantly irradiated from a site such as Lathrop Canyon, it is our responsibility, in good faith, to scientifically document the degree of danger and take appropriate remedial actions. In analyzing our data from Lathrop Canyon, it is useful to review regulations which do apply in similar situations, and to understand the intent behind those regulations.

Various agencies are involved in the process of establishing radiation regulations. The Mine Safety and Health Administration (MSHA) is responsible for setting exposure limits and establishing work procedures for occupational situations in active mines. Once the ore leaves the mines the Nuclear Regulatory Commission (NRC) regulates the milling process and waste disposal. (The NRC also regulates nuclear power and reactor wastes.) These agencies base their decisions largely on the research and recommendations of the Environmental Protection Agency (EPA) and the National Institute of Occupational Safety and Health (NIOSH), which generate "criteria documents" that become the foundation for new standards. The recommendations of the EPA and NIOSH are based on technical feasibility, and are subject to the approval of the Office of Management and Budget (OMB), which assesses the recommendations for their economical practicality. Existing regulations are currently in the process of being revised, and it is anticipated that, perhaps by the end of 1989, much stricter occupational limits will be set. (e.g., see NIOSH criteria document from October, 1987 entitled, A Recommended Standard for Occupational Exposure to Radon Progeny in Underground Mines.) Issues concerning environmental and general public (non-occupational) exposure are handled by the EPA. The Department of Energy (DOE, formerly the Atomic Energy Commission (AEC)) may be called in to clean up EPA "Superfund" sites. Numerous other national and international agencies have evolved through time to conduct research and make recommendations for the regulatory agencies, industry, and the general public. Several of these agencies are listed below:

ICRP	-	International Commission on Radiological Protection
IRPA	-	International Radiation Protection Administration
NAS-BEIR	-	National Academy of Science, Committee on the Biological Effects of Ionizing Radiation
NCRPM	-	National Council on Radiation Protection and Measurements
NEA	-	Nuclear Energy Agency
UNSCEAR	-	United Nations Scientific Committee on the Effects of Atomic Radiation
USERDA	-	United States Energy Research and Development Administration

Environmental policies generally define two categories of permissible limits: standards and guidelines. A "standard" is a rigid, enforceable value which must not be exceeded by the operations for which it was set. A "guideline" is a non-enforceable recommendation which later may be upgraded to a standard

pending further research and/or legislation. A presidential document entitled "Radiation Protection Guidance to Federal Agencies for Occupational Exposure" appeared in the Federal Register on January 27, 1987 (vol. 52, no. 17, pp. 2821-2834). This document lists three basic principles that have governed occupational radiation protection policy:

1. Any activity involving occupational exposure should be determined to be useful enough to society to warrant exposure of workers; i.e., that a finding be made that the exposure is "justified."

2. Exposure of the work force should be as low as reasonably achievable (commonly designated by the acronym 'ALARA').

3. To provide an upper limit on risk to individual workers, "limitation" of the maximum allowed individual dose is required.

These principles are helpful in establishing NPS guidelines as well.

Current federal standards for radiation protection relative to mining operations address two situations: occupational regulations concerning active mine sites, and environmental regulations concerning milled tailings disposal or storage. These standards are set with the understanding that there is no threshold below which exposure to radiation does not pose some risk to health. Stated positively, any exposure to radiation will do some damage, and should be avoided if that exposure cannot be "justified" as useful. It should also be noted that these regulations are based on exposure, as opposed to dose. "Exposure" is the amount of radiation present in an environment, representing potential health danger to an individual. "Dose" is the actual amount of radiant energy absorbed by that individual. The following discussion is based on the laws found in the Code of Federal Regulations (CFR, Title 10: Nuclear Regulatory Commission, Title 30: Mine Safety and Health Administration, and Title 40: Environmental Protection Agency), on conversations with the Radiation Programs Branch of the EPA, and on conversations with the Physical Agents Group of MSHA.

Occupational levels of alpha and gamma radiation in underground uranium mines are regulated in 30 CFR, Part 57, Subpart D. Here, it is stated that occupational yearly exposure per individual shall not exceed 4 WLM alpha (30 CFR §57.5038) or 5 REM gamma (30 CFR §57.5047d. (Refer to the glossary, pp. 16 - 18, for definition of units.) These limits are mutually exclusive, e.g., a miner may have 3 WLM alpha and 4 REM gamma exposures and remain considerably below his annual allowance. The EPA typically recommends 10% of occupational limits for the general public, based on the assumption that individuals electing to work in hazardous environments knowingly accept a higher level of risk than would be appropriate for the public at large. Accordingly, this convention yields a general public guideline of 0.4 WLM alpha and 0.5 REM gamma. The EPA further breaks down the gamma level, suggesting that 0.5 REM is a permissible individual non-occupational level, while the broad public guideline should be reduced to 0.1 REM. (Some agencies recommend the broad public guideline of 0.17 REM per year.)

Several other regulations for active underground uranium mines are pertinent to the situation at Lathrop Canyon. Occupational standards require that inactive areas with radon daughter concentrations exceeding 1 WL should be posted against unauthorized entry and designated by signs requiring the use of approved respirators (30 CFR §57.5045). Active mines with ore inventories in excess of 100,000 tons are required to seal off all abandoned areas with airtight, stable bulkheads (40 CFR §61.22). The EPA rationalizes this requirement as follows:

> The complexity in the structure of underground uranium mines, the uncertainties of in-mine control techniques, and the lack of suitable control technology to capture radon-222 being vented from mines causes the Agency (EPA) to conclude that an emission standard is not feasible. The effectiveness of techniques for radon-222 emissions is not known. This means that predictable, hence measurable, steps toward compliance with a generic emission standard cannot be identified. In this instance, section 112(e)(1) of the Clean Air Act allows the Agency to prescribe a work practice or other type standard to control the pollutant. This standard, therefore, requires that bulkheading be used to reduce emissions of radon-222 from the mines. (Federal Register, Vol. 50, No. 74, April 17, 1985, pp. 15389-15390)

Unlike the Lathrop Canyon Mines, this standard applies to large, active mines with forced-air ventilation systems, but it is important for our purposes to note that EPA advocates the use of airtight bulkheads to reduce significant radon emissions from underground uranium mines.

Regulations applying to soil concentrations of radioactive elements are covered in 40 CFR §192, entitled "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings." The waste-rock piles in Lathrop Canyon are <u>not</u> subject to these regulations, as they have not been milled. These standards are predicated on a "residential use scenario," meaning that they are geared toward ensuring safe conditions for residential areas. Again, this is clearly not the case in Lathrop Canyon. The Code specifies (§192.12) that concentration of radium-226 in land averaged over an area of 100 square meters shall not exceed background (native concentrations of radioactivity or radioactive materials in the area prior to disturbance) by more than:

1. 5 pCi/g.* averaged over the first 15 cm. of soil below the surface, and

2. 15 pCi/g. averaged over 15 cm.-thick layers of soil more than 15 cm. below the surface.

* The unit pCi/g (picocuries per gram) is the number of atomic decays per minute undergone by a radioactive species per unit mass of the sample. The decay rate of a sample, or it's "degree of radioactivity," is directly proportional to the concentration of the radioactive constituent(s) being tested. For a pure radioactive substance, this value is constant: a distinguishing characteristic of the radioactive element termed "specific activity."

The Code further stipulates (§192.21) this standard is flexible in cases where:

a. remedial action would pose a threat to the health of workers performing the reclamation.

b. remedial action would "directly produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near the site, now or in the future."

c. there is no likelihood of buildings being erected or people spending large amounts of time in the area.

d. the cost of remedial action is clearly unreasonably high relative to the benefits.

"Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly and difficult to remove, or where only minor quantities of residual radioactive materials are involved."

Finally, we must address water quality. Regulations for effluents from active uranium, radium, and vanadium mines are cited in 40 CFR §440.32. These limits are listed in Figure D:

Effluent Characteristic	Effluent Limitation	
	Maximum for any one day	Average of daily values for 30 consecutive days
TSS (Total Suspended Solids)	30 mg/l	20 mg/l
COD (Chemical Oxygen Demand)	200 mg/l	100 mg/l
Zn (Zinc)	1.0 mg/l	0.5 mg/l
Ra226 (dissolved)	10 pCi/l	3 pCi/l
Ra226 (total)	30 pCi/l	10 pCi/l
U (Uranium)	4 mg/l	2 mg/l
pH	6 - 9	6 - 9

Figure D: Limits for concentration of pollutants discharged by underground uranium, radium, and vanadium mines.

The EPA has identified a list of 128 priority pollutants for water. Permissible limits have not yet been developed for some of these pollutants, but established standards for the rest are documented in the EPA publication, QUALITY CRITERIA FOR WATER 1986 (EPA 440/5-86-001). These values are summarized in tabular form by the Water Resources Division of the National Park Service in their publication, Monitoring Stream Water for Land-Use Impacts, (1987). These tables are included in Appendix 3, and will be useful in reviewing current and future water analysis data received from the USGS.

GLOSSARY OF RADIOLOGICAL TERMS

Alpha energy - Alpha energy particles are emitted from atomic nuclei with varying degrees of energy, but the energy from any radionuclide is characteristic and consistent. For example, RaA emits a characteristic 6.0 MeV alpha particle and RaC' emits a characteristic 7.7 MeV alpha particle.

Alpha particle - A positively charged particle composed of 2 neutrons and 2 protons released by some atoms undergoing radioactive decay. The particle is identical to the nucleus of a helium atom.

Atomic mass - The sum of the number of protons and neutrons in the nucleus of an atom.

Atomic number - The number of protons in the nucleus of an atom.

Background - The radioactivity which is inherent in the environment where specific radiation measurements, exclusive of the general environment, are desired. In this situation, the background radiation must be first determined and then subtracted from the total count.

Beta particle - A negatively charged particle similar to an electron emitted by some atoms undergoing radioactive decay. Beta particles are more penetrating but less ionizing than alpha particles.

Condensation nuclei - The small dust and aerosol particles in the atmosphere to which the atomic-sized radon daughters readily attach. Condensation nuclei are generally in the 0.2- to 0.3-micron range.

Curie (Ci) - A quantitative measure of radioactivity. One curie equals 2.22×10^{12} disintegrations per minute (dpm).

Decay series - The consecutive members of radioactive family of elements. A complete series commences with a long-lived parent such as U-238 and ends with stable element such as Pb-206.

Disintegrations per minute (dpm) - The radioactive decay rate, determined from the count rate on the instrument divided by the the gross counting efficiency of the instrument.

Dose - The amount of absorbed radiant energy. Usually given in REMs, RADs, or REPs. These units are roughly 100 ergs per gram of tissue.

Electrons - The orbital negatively charged particles surrounding the nucleus of an atom.

Electrons volt (eV) - The amount of energy required to move one electron through a difference in potential of one volt. The unit is equal to 1.6×10^{12} erg.

Equilibrium - The state at which the radioactivity of consecutive elements within a radioactive series is neither increasing nor decreasing.

Exposure - The amount of radiation present in an environment, not necessarily indicative of absorbed energy, but representative of potential health damage to the individual present. Working level hours (WLH) are one way of measuring exposure.

Gamma radiation - A true ray of energy in contrast to beta and alpha radiation. The properties are similar to X-rays and other electromagnetic waves. Gamma radiation is highly penetrating but relatively low in in ionizing potential.

Half-life - The time required for half of the atoms of a radioactive element to undergo decay.

Ionization - The breakdown of a molecule into its unstable charged components consisting of either atoms or radicals. This breakdown can be caused by several methods, one of which is ionizing radiation.

Ionizing radiation - Radiation capable of providing sufficient energy to ionize or break down molecules into charged atoms.

Neutron - Electrically neutral particles in the nucleus of an atom.

Nucleus - The center part of an atom containing protons and neutrons.

Picocurie (pCi) - A quantitative measure of radioactivity equal to $1x10^{-12}$ curie or 2.22 dpm.

Protons - Positively charged particles in the atomic nucleus. The number of protons in an atom is the atomic number of the element.

Radiation Absorbed Dose (RAD) - The unit denoting absorption of 100 ergs of radiant energy per gram of absorbing materials.

Radioactivity - Spontaneous release of particles and energy by the nucleus of an unstable atom.

Radionuclide - A radioactive atom.

Radium - Generally refers to Ra-226, the parent of radon gas in the uranium decay series.

Radium A - Po-218, the first daughter of Rn-222. It emits a 6.0 MeV alpha particle and has a half-life of approximately 3 minutes.

Radium B - Pb-214, the second daughter of Rn-222. It emits beta and gamma radiation and has a half-life of about 27 minutes.

Radium C - Bi-214, the third daughter of Rn-222. It emits a beta particle and a strong gamma ray and has a half-life of about 20 minutes.

Radium C' - Po-214, the fourth daughter of Rn-222. It emits a 7.7 MeV alpha particle and has a half-life of only 164 microseconds. Because of its extremely short half-life, very few atoms of RaC' can be present and its activity is always equal to the activity of RaC.

Radium D - Pb-210, is technically not considered one of the short-lived daughters of Rn-222 because of the relatively long half-life of 22 years. The long half-life prevents RaD and successive decay members from contributing much activity over short periods of time.

Radon - Normally the noble gaseous element (Rn-222) in the U-238 decay series. The immediate parent of Po-218 (RaA).

Radon daughters - The four short-lived elements which succeed radon in the U-238 decay series. These include Po-218(RaA), Pb-214 (RaB), Bi-214 (RaC), and Po-214 (RaC'). They have an average combined half-life of about 30 minutes.

Roentgen - A primary unit of radiation exposure. Technically, it is defined as that quantity of X-ray or gamma radiation that produces 1 electrostatic unit of electrical charge per 0.001293 gram of air.

Roentgen Equivalent Man (REM) - The amount of ionizing radiation that when absorbed by a person is equivalent to one roentgen of X-ray or gamma radiation.

Uranium - Refers normally to U-238, although about 0.7 percent U-235, the fissionable component, is present in the natural state.

Uraniun series - The 15 radioactive elements commencing with U-238 and culminating in stable Pb-206.

Working level (WL) - An atmospheric concentration of radon (Rn-222) daughters which will deliver 1.3×10^5 MeV of alpha energy per liter of air in decaying through RaC' (Po-214).

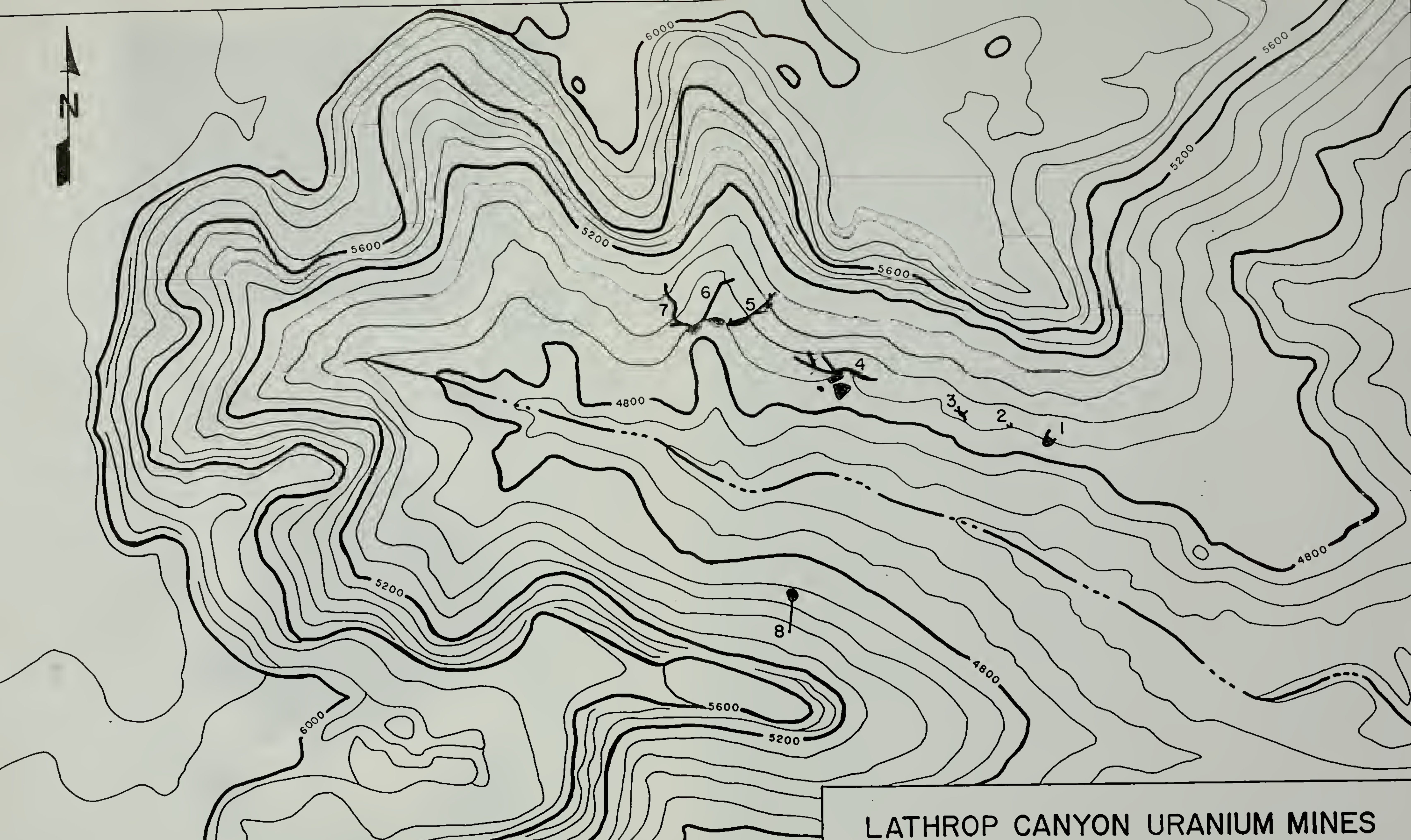
Working level hour (WLH) - An exposure equivalent to 1 working level of radon daughters for 1 hour.

Working level month (WLM) - An exposure equivalent to 1 working level of radon daughters for 173 hours.

* Taken from "Radiation Monitoring," a handbook prepared by the U.S. Department of Labor, Mine Safety and Health Administration (MSHA), 1979.

APPENDIX 2

ILLUSTRATIONS AND CHARTS



LATHROP CANYON URANIUM MINES

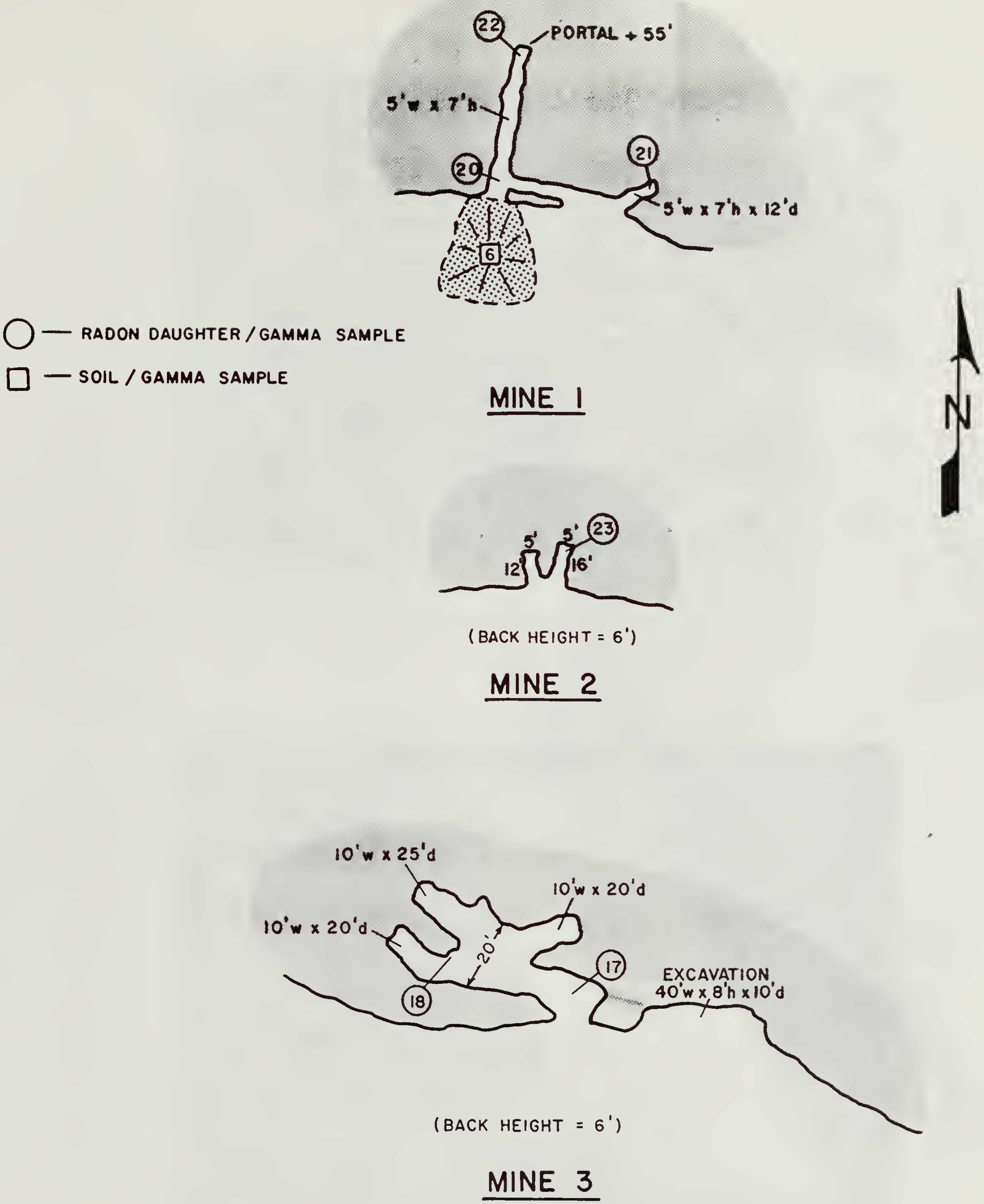
CANYONLANDS NATIONAL PARK, UTAH

CONTOUR INTERVAL: 80'
SCALE: 1" = 500'

UPHEAVAL DOME QUADRANGLE
T27S, R19E, SEC. 34 & 35

Mine 2.

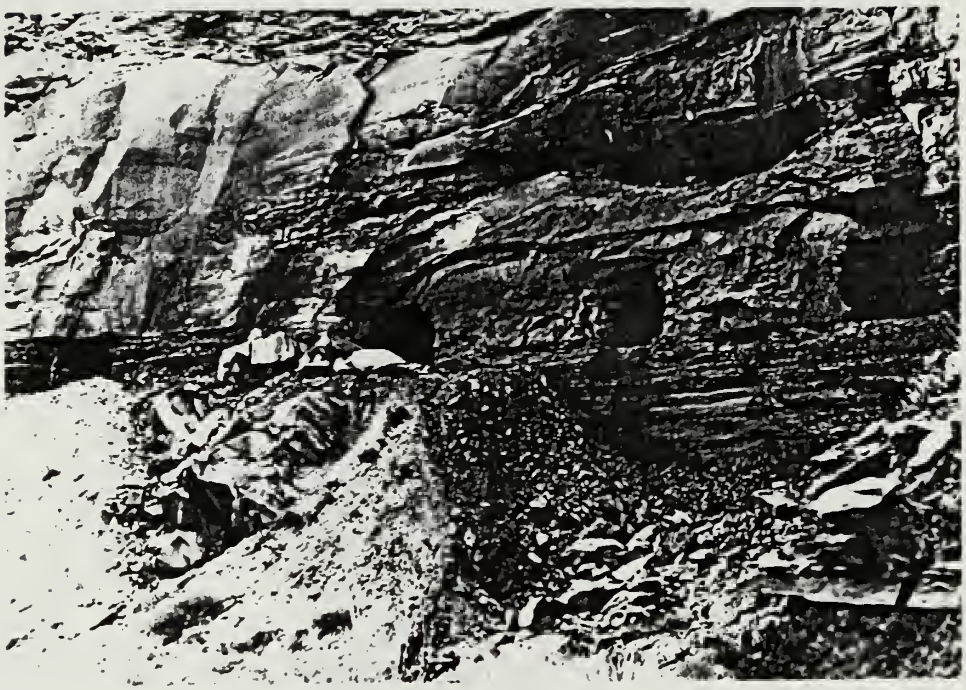
Artifacts in Mine 3. Note muddy floor
and poor rock conditions at the portal.



SCALE: 1" = 50'

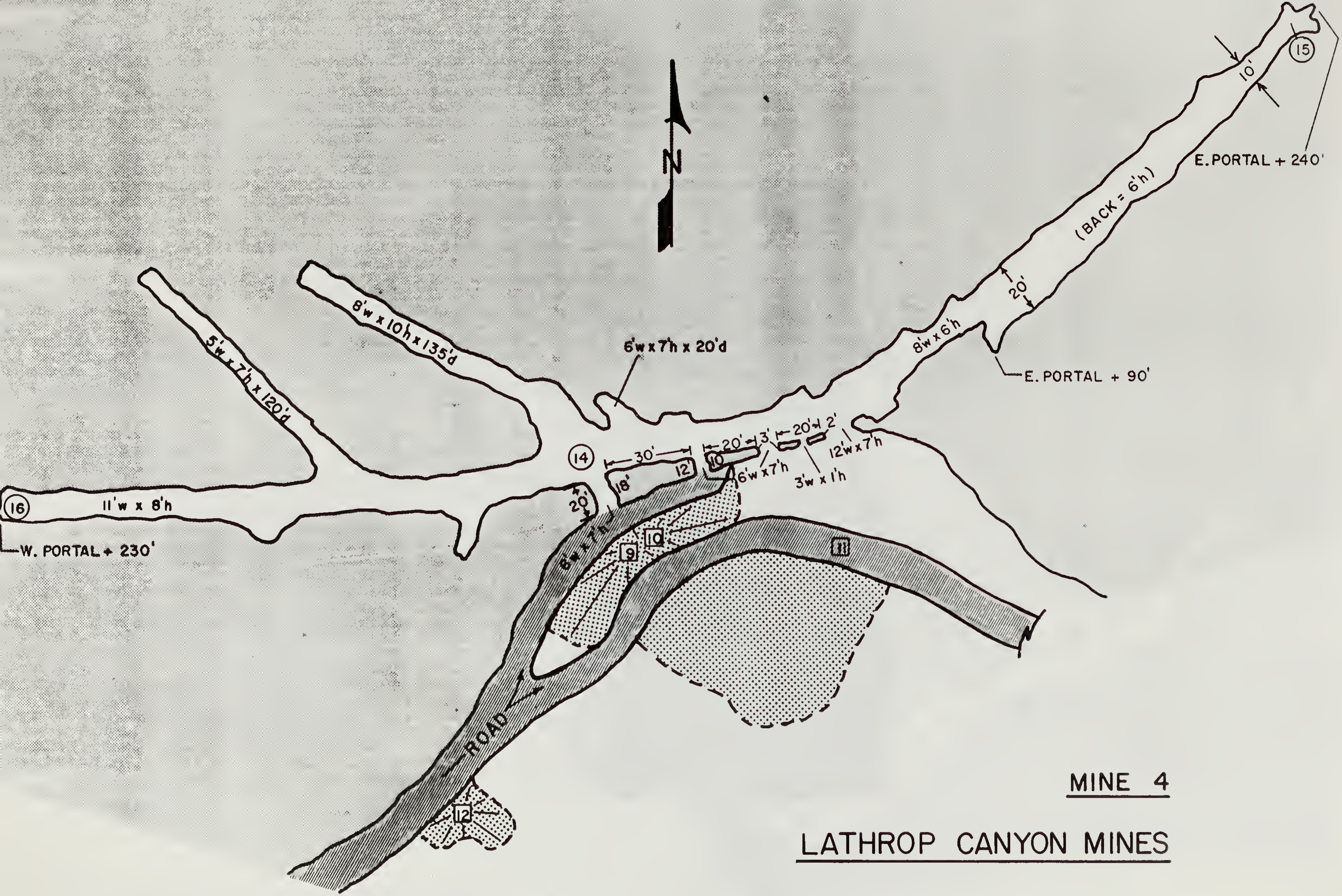
LATHROP CANYON MINES

FIGURE 2a



Mine 4, looking west.

Inside Mine 4, looking out through east portal. Note crack in floor near exposed ledge. Narrow pillar (slab between openings) offers little support to overhanging rock.

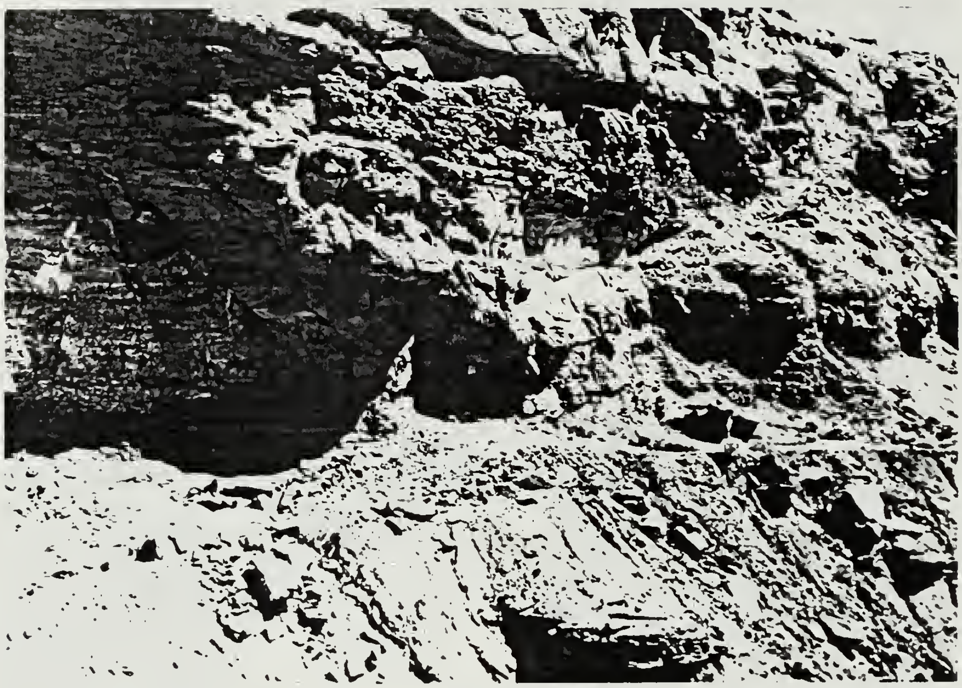


SCALE: 1" = 50'

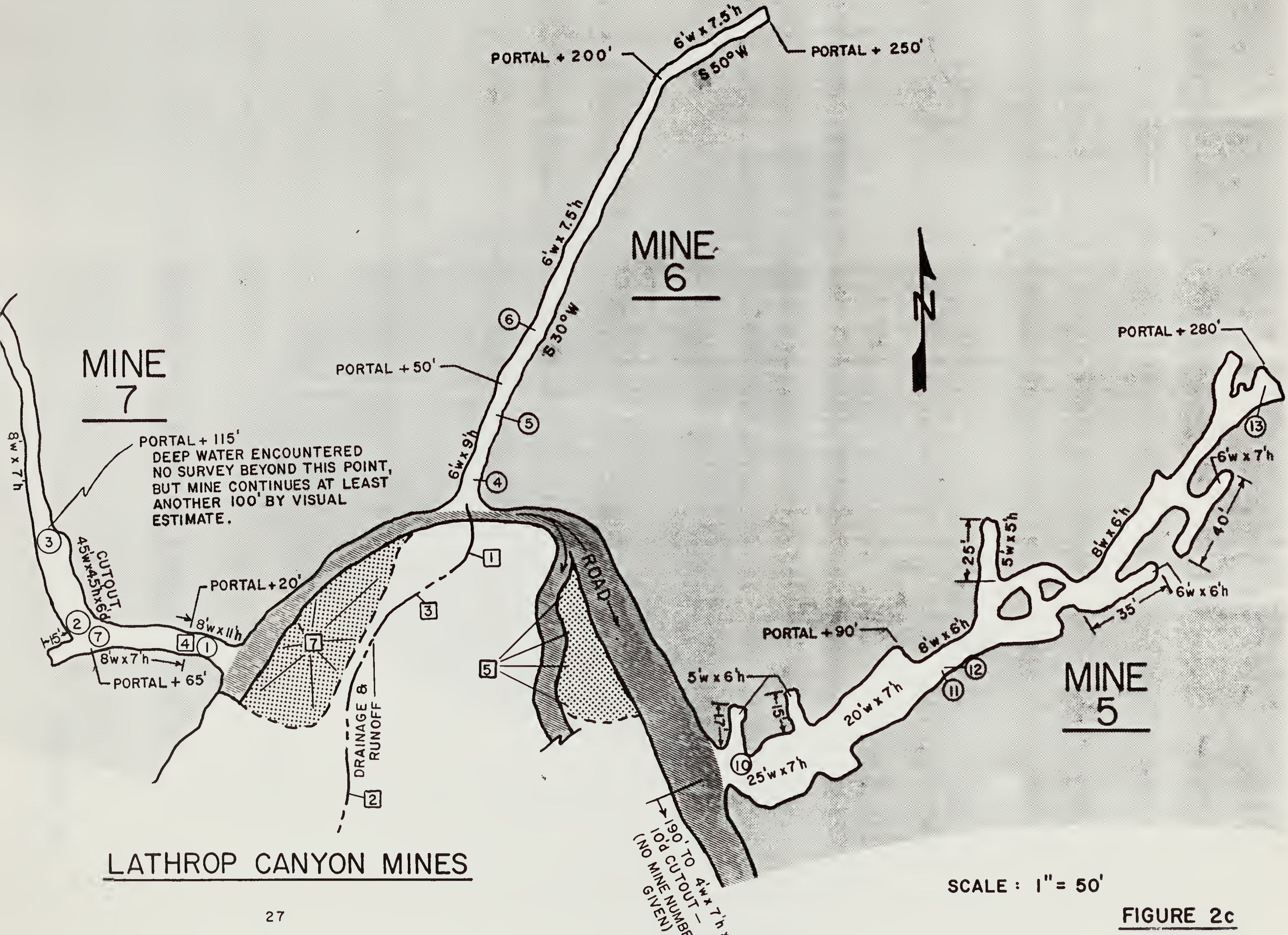
MINE 4

LATHROP CANYON MINES

FIGURE 2b



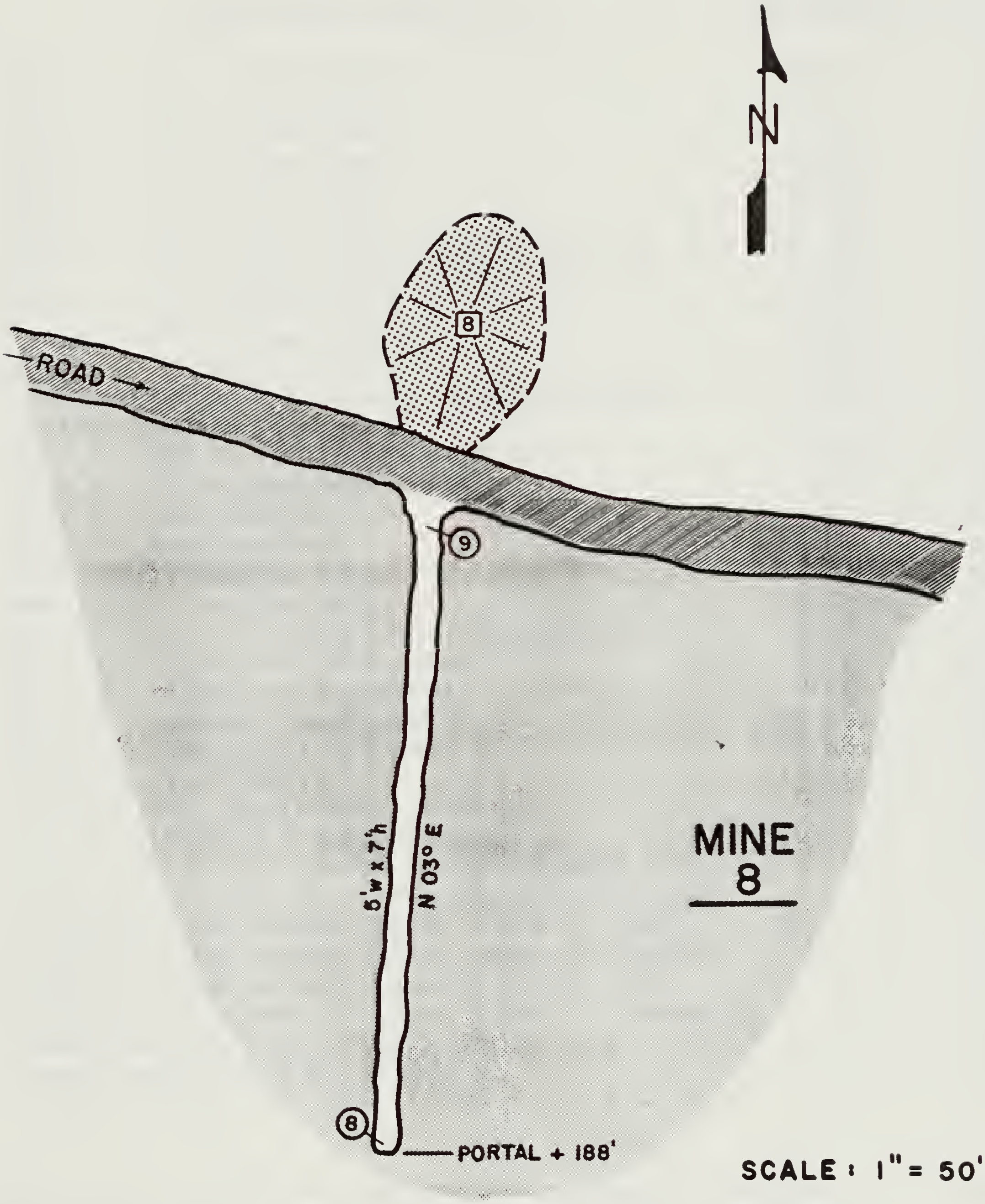
Mine 5, looking northeast from Mine 7.



LATHROP CANYON MINES

SCALE : 1" = 50'

FIGURE 2c



LATHROP CANYON MINES

FIGURE 2d

CANYONLANDS NATIONAL PARK

Lathrop Canyon Uranium Mines - Radon Daughter and Gamma Readings

08/30/88 - 09/01/88

SAMPLE #	SAMPLE IDENTIFICATION	RADON DAUGHTERS (WL alpha)	GAMMA (mR/hr)
1	Mine 7 - 10' in from portal	0.08	0.18
2	Mine 7 - 66' in from portal	0.06	0.23
3	Mine 7 - 114' in from portal	0.05	0.41
4	Mine 6 - 10' in from portal	0.02	0.08
5	Mine 6 - 39' in from portal	0.02	0.06
6	Mine 6 - 75' in from portal	0.09	0.07
7	Mine 7 - 10' in from portal, disturbing dust	0.13	0.18
8	Mine 8 - 188' in from portal (terminus)	0.02	0.03
9	Mine 8 - 10' in from portal	0.01	0.02
10	Mine 5 - 10' in from portal	0.49	0.53
11	Mine 5 - 100' in from portal	0.62	0.52
12	Mine 5 - 100' in from portal, disturbing dust	0.51	-
12a	Mine 5 - 180' in from portal	-	0.46
13	Mine 5 - 280' in from portal (terminus)	1.48	-
14	Mine 4 - 25' in from west portal	0.88	0.26
15	Mine 4 - east terminus	1.39	0.43
16	Mine 4 - west terminus	0.63	0.12
17	Mine 3 - 10' in from portal	0.23	0.47
18	Mine 3 - 50' in from portal	0.25	0.48
19	Unused filter - reading taken to check inst.	0.00	-
20	Mine 1 - 10' in from west portal	0.01	0.17
21	Mine 1 - terminus, east portal	0.04	0.22
22	Mine 1 - terminus, west drift	0.02	0.22
23	Mine 2 - terminus, east portal	0.02	0.44
SS1	15' elev. below Mine 6	-	0.15
SS2	115' out from Mine 6 along drainage	-	0.15
SS3	42' out from Mine 6 along drainage	-	0.15
SS4	Mine 7, 20' in from portal (Note: reading was 0.18 previous day when radon sample was taken)	-	0.32
SS5a	Waste-rock pile between Mines 5 and 6 - top	-	0.27
SS5b	Waste-rock pile between Mines 5 and 6 - bottom	-	0.40
SS7a	Waste-rock pile between Mines 6 and 7 - top	-	0.25
SS7b	Waste-rock pile between Mines 6 and 7 - bottom	-	0.25
SS9	Waste-rock pile below Mine 4, above road	-	0.18
SS11	Wash crossing road below Mine 4	-	0.17
SS12	Waste-rock pile 120' west of Mine 4	-	0.18

Note: The Kusnetz method was used for radon daughter sampling. The alpha detector and counter were checked for accuracy against a calibrated Thorium-230 source before and after readings were taken each day. The air sampling pump used to collect air samples was calibrated on 08/24/88 at the Mine Safety and Health Administration (MSHA) and corrected for elevation and temperature. The gamma scintillometer was calibrated on 08/24/88 against a standard at the Bureau of Mines.

Figure 3

CANYONLANDS NATIONAL PARK

Lathrop Canyon Uranium Mines - Estimated Mine and Waste-Rock Volumes

08/30/88 - 09/01/88

LOCATION	VOLUME (cu.ft.)
Mine 1	3,700
Mine 2	800
Mine 3	6,100
Mine 4	65,500
Mine 5	30,000
Mine 6	11,700
Mine 7	7,100
Mine 8	6,600
TOTAL MINE VOLUME	131,500
Waste-rock pile below Mine 1	3,300
Waste-rock pile below Mine 4, above road	7,500
Waste-rock pile below Mine 4, below road	12,700
Waste-rock pile, 120' west of Mine 4	1,500
Waste-rock pile between Mines 5 and 6	3,800
Waste-rock pile between Mines 6 and 7	9,000
Waste-rock pile below Mine 8	6,000
TOTAL WASTE-ROCK VOLUME	43,800

MINE VOLUME : WASTE-ROCK VOLUME = 3:1

Figure 4

CANYONLANDS NATIONAL PARK

Lathrop Canyon Uranium Mines - Soil Sample Assays - 08/30/88 - 09/01/88

SAMPLE #	SAMPLE IDENTIFICATION	TOTAL URANIUM (% U_3O_8)	RADIUM 226 pCi/g	GROSS ALPHA pCi/g	GROSS BETA pCi/g
1	Composite surface - mud 15' elev.below portal mine 6	0.002	33(±4)	70(±11)	110(±10)
2	Composite surface - 115' out from Mine 6, across drainage	lt 0.001	4.6(±1.6)	25(±6)	32(±8)
3	Composite surface - 42' out from Mine 6, across drainage	lt 0.001	4.8(±1.6)	13(±5)	30(±7)
4	Composite surface - Mine 7, dust on floor, 20' in from portal	0.025	61(±6)	280(±20)	240(±20)
5	Composite surface - base of waste-rock pile between Mines 5 and 6	0.075	54(±6)	1040(±40)	880(±30)
6	Composite at 6" depth - waste-rock pile below Mine 1	0.046	140(±10)	790(±30)	610(±30)
7	Composite surface - waste-rock pile between Mines 6 and 7	0.021	81(±4)	370(±30)	350(±20)
8	Composite surface - waste-rock pile below Mine 8	0.001	6.3(±1.2)	31(±7)	52(±9)
9	Composite at 1' depth - waste-rock pile below Mine 4, above road	0.017	47(±3)	270(±20)	220(±20)
10	Composite surface - waste-rock pile below Mine 4, above road	0.019	91(±5)	520(±30)	430(±20)
11	Composite surface - wash crossing road below Mine 4	0.004	8.6(±2.2)	43(±8)	69(±10)
12	Composite surface - waste-rock pile 120' west of Mine 4	0.020	54(±5)	290(±20)	240(±20)

Figure 5a

CANYONLANDS NATIONAL PARK

Lathrop Canyon Uranium Mines - Uranium/Radium Ratios - 08/30/88 - 09/01/88

SAMPLE #	SAMPLE IDENTIFICATION	TOTAL URANIUM ppm	RADIUM 226 pCi/g	RATIO* ppm U : pCi/g Ra
1	Composite surface - mud 15' elev.below portal mine 6	17	33(±4)	0.52 : 1
2	Composite surface - 115' out from Mine 6, across drainage	lt 8	4.6(±1.6)	1.74 : 1
3	Composite surface - 42' out from Mine 6, across drainage	lt 8	4.8(±1.6)	1.67 : 1
4	Composite surface - Mine 7, dust on floor, 20' in from portal	212	61(±6)	3.48 : 1
5	Composite surface - base of waste-rock pile between Mines 5 and 6	636	54(±6)	11.78 : 1
6	Composite at 6" depth - waste-rock pile below Mine 1	390	140(±10)	2.79 : 1
7	Composite surface - waste-rock pile between Mines 6 and 7	178	81(±4)	2.20 : 1
8	Composite surface - waste-rock pile below Mine 8	8	6.3(±1.2)	1.27 : 1
9	Composite at 1' depth - waste-rock pile below Mine 4, above road	119	47(±3)	2.53 : 1
10	Composite surface - waste-rock pile below Mine 4, above road	161	91(±5)	1.77 : 1
11	Composite surface - wash crossing road below Mine 4	34	8.6(±2.2)	3.95 : 1
12	Composite surface - waste-rock pile 120' west of Mine 4	169	54(±5)	3.13 : 1

* In equilibrium, total uranium and radium should be directly proportional by a factor of 3 ppm U : 1 pCi/g Ra. Our data indicate a disequilibrium hypothetically caused by leaching of the uranium, which is more soluble than radium.

Figure 5b

CANYONLANDS NATIONAL PARK

Lathrop Canyon - USGS Water Analysis Summary - 04-14-88

PARAMETER* (units)	SITE 1	SITE 2	SITE 3	SITE 4
Alkalinity* (mg/l as $CaCO_3$)	351	384	309	255
Barium dissolved* (ug/l as Ba)	52	-	-	53
Beryllium dissolved* (ug/l as Be)	0.05	-	-	2
Cadmium dissolved* (ug/l as Cd)	1	-	-	3
Calcium dissolved (mg/l as Ca)	31	150	70	87
Chloride dissolved (mg/l as Cl)	150	3600	1200	900
Chromium dissolved* (ug/l as Cr)	5	-	-	20
Cobalt dissolved (ug/l as Co)	3	-	-	9
Copper dissolved* (ug/l as Cu)	10	-	-	30
Fluoride dissolved** (mg/l as F)	0.50	0.50	0.40	0.50
Gross Alpha**, HS, Th, FF (pCi/l)	90.6	621	3210	60.6
Gross Alpha**, HS, U, FF (ug/l)	86.8	618	2980	58.6
Gross Beta, HS, CS-137, FF (pCi/l)	73.4	219	2020	62.7
Gross Beta, HS, Sr-90, FF (pCi/l)	49	140	1360	42.4
Iron dissolved* (ug/l as Fe)	11	-	-	18
Lead dissolved* (ug/l as Pb)	10	-	-	30
Lithium dissolved (ug/l as Li)	160	-	-	360
Magnesium dissolved (mg/l as Mg)	49	71	109	77
Manganese dissolved* (ug/l as Mn)	1	-	-	3
Molybdenum dissolved (ug/l as Mo)	30	-	-	30
Nickel dissolved* (ug/l as Ni)	10	-	-	30
Nitrogen Nitrite + Nitrate dissolved* (mg/l as N)	0.100	0.450	0.160	0.500
pH* (standard units)	8.50	7.90	8.40	8.10
pH (laboratory units)	8.50	7.90	8.30	8.00
Potassium dissolved (mg/l as K)	29	25	20	16
Radium-228,RC, with 226, FF (pCi/l)	0.47	1.7	0.479	1.24
Radium-226 dissolved, RN** (pCi/l)	.182	92.9	39.6	0.294
Silica dissolved (mg/l as SiO_2)	15	8.4	8.9	12
Silver dissolved* (ug/l as Ag)	7	-	-	3
Sodium dissolved (mg/l as Na)	230	2600	1400	620
Specific Conductance (us/cm @ 25°C)	1540	11600	6940	4000
Strontium dissolved (ug/l as Sr)	1200	-	-	4500
Sulfate dissolved (mg/l as SO_4)	270	780	1600	510
Uranium-234, alpha spec (pCi/l)	35.0	46.3	1200	18.6
Uranium-235, alpha spec (pCi/l)	1.03	0.319	30.9	0.508
Uranium-238, alpha spec (pCi/l)	25.4	8.47	869.0	13.7
Vanadium dissolved (ug/l as V)	9	-	-	18
Water Temperature ($^{\circ}$C)	20.0	12.5	11.5	21.0
Zinc dissolved* (ug/l as Zn)	3	-	-	19

* EPA standards established (see Appendix 3)
** standards cited in footnote 2, Appendix 3

Figure 6

APPENDIX 3

EPA WATER QUALITY CRITERIA

* taken from Monitoring Stream Water for Land-Use Impacts: A Training Manual for Natural Resource Management Specialists, (1987), National Park Service, Water Resources Division.

EPA WATER QUALITY CRITERIA

The following summary chart for water quality criteria contains excerpts from Quality Criteria for Water: 1986 (USEPA, 1986), which summarize available information on toxicities and criteria levels for chemical elements, man-made compounds, and the natural constituents or characteristics found in water. These criteria levels reflect the latest knowledge on the effects of surface-water and ground-water pollutants on health and welfare.

A brief explanation for interpreting the summary table follows. For a complete explanation of the derivations used in computing the chemical criteria shown, refer to appendices A through C in the original document (USEPA, 1986).

Pollutant levels for fresh water are divided into chronic and acute toxicity levels. Where information is sufficient, acute (short-term) toxicity levels are given that estimate the highest one-hour average concentration or a single grab sample concentration that should not produce unacceptable effects on aquatic organisms. Likewise, chronic (long-term) toxicities are diplayed when enough information is available to estimate the highest four-day average concentration (or the average concentration of several samples collected and analyzed over a period of time) that should not cause unacceptable toxicity during a long-term exposure. Both chronic and acute toxicity levels for many parameters are related to water quality characteristics such as pH, salinity, or hardness, and the toxicity concentration levels are a function of these pertinent character-istics. The criteria levels are maximum values except in the case of alkalinity, which is based on a minimum concentration needed to support fisheries unless background levels are naturally lower.

The categories for 1) water and fish ingestion and 2) fish consumption only refer to the effects of consumption of the constituents on human health. The concentrations shown here represent daily intake limits for each water quality parameter; that is, a constituent would be considered a health hazard to humans if ingested via untreated stream water or fish in a concentration greater than the criterion given.

It should be noted that a number of chemical parameters listed have exceedingly small criteria levels reported for human health considerations, and many are given in fractions of a nanogram (ng). In routine water quality sampling, very few laboratories are able to measure chemicals to this level of accuracy. These low levels indicate the high toxicity and potential health hazards of these chemicals and suggest that any amount found in a water sample requires that more extensive testing be done, and the proper authorities should be notified immediately.

The EPA and its predecessor agencies began publishing information on ambient water quality criteria beginning in 1968, followed by revisions in 1972 and 1976. The latest update of Quality Criteria for

Water (USEPA, 1986) can be obtained (for a fee) by writing to the following address:

U.S. Government Printing Office
Superintendent of Documents
N. Capitol and H. Street N.W.
Washington, D.C. 20401

The EPA is continuously updating and revising existing criteria and recommendations as well as developing new ones. These releases will also be made available to the public as they are completed. Questions regarding criteria level determinations or applicability can be addressed by contacting the following:

U.S. Environmental Protection Agency
Criteria and Standards Division
WH585
401 M Street SW
Washington, D.C. 20460

REFERENCE

U.S. Environmental Protection Agency (USEPA). 1986. Quality criteria for water 1986. U.S. Government Printing Office, Washington, DC. 265 pp.

U.S. Environmental Protection Agency
Office of Water Regulations and Standards
Standards Branch (WH-585)
401 M Street S.W.
Washington, D.C. 20460
update 1.0
September 2, 1986

	PRIORITY POLLUTANT	CARCINOGEN	CONCENTRATIONS IN µg/L FRESH ACUTE CRITERIA	FRESH CHRONIC CRITERIA	UNITS PER LITER WATER AND FISH INGESTION	FISH CONSUMPTION ONLY	DRINKING WATER M.C.L.[1,2]	DATE/REFERENCE
ACENAPTHENE	Y	N	*1,700.	*520.				1980 FR
ACROLEIN	Y	N	*68.	*21.	320. µg	780. µg		1980 FR
ACRYLONITRILE	Y	Y	*7,550.	*2,600.	0.058µg**	0.65µg**		1980 FR
ALDRIN	Y	Y	3.0		0.074ng**	0.079ng**		1980 FR
ALKALINITY	N	N		20,000.				1976 RB
AMMONIA	N	N	CRITERIA ARE pH AND TEMPERATURE DEPENDENT - SEE DOCUMENT					1985 FR
ANTIMONY	Y	N	*9,000.	*1,600.	146 µg	45,000 µg		1980 FR
ARSENIC	Y	Y			2.2ng**	17.5ng**	0.05mg	1980 FR
ARSENIC (PENT)	Y	Y	*850.	*48				1985 FR
ARSENIC (TRI)	Y	Y	360.	190.				1985 FR
ASBESTOS	Y	Y			30k f/L**			1980 FR
BACTERIA	N	N	FOR PRIMARY RECREATION AND SHELLFISH USES - SEE DOCUMENT				<1/100ml	1986 FR
BARIUM	N	N			1. mg		1.0mg	1976 RB
BENZENE	Y	Y	*5,300.		0.66µg**	40. µg**		1980 FR
BENZIDINE	Y	Y	*2,500		0.12ng**	0.53ng**		1980 FR
BERYLLIUM	Y	Y	*130	*5.3	6.8ng**	117. ng**		1980 FR
BHC	Y	N	*100					1980 FR
CADMIUM	Y	N	3.9•	1.1•	10. µg		0.010mg	1985 FR
CARBON TETRACHLORIDE	Y	Y	*35,200.		0.4µg**	6.94µg**		1980 FR
CHLORDANE	Y	Y	2.4	0.0043	0.46ng**	0.48ng**		1980 FR
CHLORINATED BENZENES	Y	Y	*250	*50.	488µg			1980 FR
CHLORINATED NAPHTHALENES	Y	N	*1,600					1980 FR
CHLORINE	N	N	19	11.				1985 FR
CHLOROALKYL ETHERS	Y	N	*238,000					1980 FR
CHLOROETHYL BIS-2	Y	Y			0.03µg**	1.36µg**		1980 FR
CHLOROFORM	Y	Y	*28,900	*1,240	0.19µg**	15.7µg**		1980 FR
CHLOROISOPROPYL (BIS-2)	Y	N			34.7µg	4.36mg		1980 FR
CHLOROMETHYL ETHER (BIS)	Y	N			0.00000376ng**	0.00184µg**		1980 FR
CHLOROPHENOL 2	Y	N	*4,380	*2,000.				1980 FR
CHLOROPHENOL 4	N	N						1980 FR
CHLOROPHENOXY HERBICIDES (2,4,5,-TP)	N	N			10. µg			1980 FR
CHLOROPHENOXY HERBICIDES (2,4-D)	N	N			100. µg			1976 RB
CHLORO-4 METHYL-3 PHENOL	N	N	*30					1980 FR
CHROMIUM (HEX)	Y	N	16	11	50. µg		0.05mg	1985 FR
CHROMIUM (TRI)	N	N	1,700 •	210. •	170. mg	3,433 mg	0.05mg	1985 FR
COLOR	N	N	NARRATIVE STATEMENT - SEE DOCUMENT					1976 RB
COPPER	Y	N	18 •	12. •				1985 FR
CYANIDE	Y	N	22.	5.2	200. µg			1985 FR
DDT	Y	Y	1.1	0.001	0.024ng**	0.024ng**		1980 FR
DDT METABOLITE (DDE)	Y	Y	*1,050.					1980 FR
DDT METABOLITE (TDE)	Y	Y	*0.06					1980 FR
DEMETON	Y	N		0.1				1976 RB
DIBUTYL PHTHALATE	Y	N			35. mg	154 mg		1980 FR
DICHLOROBENZENES	Y	N	*1,120	*763	400 µg	2.6mg		1980 FR
DICHLOROBENZIDINE	Y	Y			0.01µg**	0.02µg**		1980 FR
DICHLOROETHANE 1,2	Y	Y	*118,000	*20,000.	0.94µg**	243 µg**		1980 FR
DICHLOROETHYLENES	Y	Y	*11,600		0.033µg**	1.85µg**		1980 FR
DICHLOROPHENOL 2,4	N	N	*2,020.	*365.	3.09mg			1980 FR
DICHLOROPROPANE	Y	N	*23,000	*5,700.				1980 FR
DICHLOROPROPENE	Y	N	*6,060	*244	87. µg	14.1mg		1980 FR
DIELDRIN	Y	Y	2.5	0.0019	0.071ng**	0.076ng**		1980 FR
DIETHYL PHTHALATE	Y	N			350. mg	1.8g		1980 FR
DIMETHYL PHENOL 2,4	Y	N	*2,120.					1980 FR
DIMETHYL PHTHALATE	Y	N			313. mg	2.9g		1980 FR
DINITROTOLUENE 2,4	N	Y			0.11µg**	9.1µg**		1980 FR
DINITROPHENOLS	Y	N			70. µg	14.3mg		1980 FR
DINITROTOLUENE	N	Y	*330	*230				1980 FR
DINITRO-O-CRESOL 2,4	Y	N			13.4µg	765 µg		1980 FR
DIOXIN (2,3,7,8-TCDD)	Y	Y	*<0.01	*<0.00001	0.000013ng**	0.000014ng**		1984 FR
DIPHENYLHYDRAZINE	Y	N			42. ng**	0.56µg**		1980 FR
DIPHENYLHYDRAZINE 1,2	Y	N	*270					1980 FR
DI-2-ETHYLHEXYL PHTHALATE	Y	N			15. mg	50 mg		1980 FR
ENDOSULFAN	Y	N	0.22	0.056	74 µg	159 µg		1980 FR
ENDRIN	Y	N	0.18	0.0023	1 µg		0.0002mg	1980 FR
ETHYLBENZENE	Y	N	*32,000		1.4mg	3.28mg		1980 FR
FLUORANTHENE	Y	N	*3,980		42. µg	54. µg		1980 FR
GASES, TOTAL DISSOLVED	N	N	NARRATIVE STATEMENT - SEE DOCUMENT					1976 RB
GUTHION	N	N		0.01				1976 RB
HALOETHERS	Y	N	*360	*122.				1980 FR
HALOMETHANES	Y	Y	*11,000.		0.19µg**	15.7µg**		1980 FR
HEPTACHLOR	Y	Y	0.52	0.0038	0.28ng**	0.29ng**		1980 FR
HEXACHLOROETHANE	N	Y	*980	*540	1.9µg	8.74µg		1980 FR
HEXACHLOROBENZENE	Y	N			0.72ng**	0.74ng**		1980 FR
HEXACHLOROBUTADIENE	Y	Y	*90.	*9.3	0.45µg**	50. µg**		1980 FR
HEXACHLOROCYCLOHEXANE (LINDANE)	Y	Y	2.0	0.08			0.004mg	1980 FR
HEXACHLOROCYCLOHEXANE - ALPHA	Y	Y			9.2ng**	31. ng**		1980 FR
HEXACHLOROCYCLOHEXANE - BETA	Y	Y			16.3ng**	54.7ng**		1980 FR
HEXACHLOROCYCLOHEXANE - GAMMA	Y	Y			18.6ng**	62.5ng**		1980 FR
HEXACHLOROCYCLOHEXANE - TECHNICAL	Y	Y			12.3ng**	41.4ng**		1980 FR
HEXACHLOROCYCLOPENTADIENE	Y	N	*7.	*5.2				1980 FR

U.S. Environmental Protection Agency
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update 1.0
September 2, 1986

	PRIORITY POLLUTANT	CARCINOGEN	CONCENTRATIONS IN µg/L		UNITS PER LITER			
			FRESH ACUTE CRITERIA	FRESH CHRONIC CRITERIA	WATER AND FISH INGESTION	FISH CONSUMPTION ONLY	DRINKING WATER M.C.L.[1,2]	DATE/ REFERENCE
IRON	N	N		1,000.	0.3mg			1976 RB
ISOPHORONE	Y	N	*117,000.		5.2mg	520.mg		1980 FR
LEAD	Y	N	82.+	3.2+	50.µg		0.05mg	1985 FR
MALATHION	N	N		0.01				1976 RB
MANGANESE	N	N			50.µg	100 µg		1976 RB
MERCURY	Y	N	2.4	0.012	144.ng	146 ng	0.002mg	1985 FR
METHOXYCHLOR	N	N		0.03	100.µg		0.1mg	1976 RB
MIREX	N	N		0.001				1976 RB
MONOCHLOROBENZENE	Y	N			488.µg			1980 FR
NAPHTHALENE	Y	N	*2,300.	*620.				1980 FR
NICKEL	Y	N	1,800.+	96.+	13.4µg	100 µg		1980 FR
NITRATES	N	N			10.mg		10.mg	1976 RB
NITROBENZENE	Y	N	*27,000.		19.8mg			1980 FR
NITROPHENOLS	Y	N	*230.	*150.				1980 FR
NITROSAMINES	Y	Y	*5,850.		0.8ng**	1240.ng**		1980 FR
NITROSODIBUTYLAMINE N	Y	Y			6.4ng**	587.ng**		1980 FR
NITROSODIETHYLAMINE N	Y	Y			0.8ng**	1,240.ng**		1980 FR
NITROSODIMETHYLAMINE N	Y	Y			1.4ng**	16,000.ng**		1980 FR
NITROSODIPHENYLAMINE N	Y	Y			4,900.ng**	16,100.ng**		1980 FR
NITROSOPYRROLIDINE N	Y	Y			16.ng**	91,900.ng**		1980 FR
OIL AND GREASE	N	N	NARRATIVE STATEMENT - SEE DOCUMENT					1976 RB
OXYGEN DISSOLVED	N	N	WARMWATER AND COLDWATER CRITERIA MATRIX - SEE DOCUMENT					1986 FR
PARATHION	N	N		0.04				1976 RB
PCBs	Y	Y	2.0	0.014	0.079ng**	0.079ng**		1980 FR
PENTACHLORINATED ETHANES	Y	N	*7,240.	*1,100.				1980 FR
PENTACHLOROBENZENE	Y	N			74.µg	85.µg		1980 FR
PENTACHLOROPHENOL	Y	N	*55.	*3.2	1.01mg			1980 FR
PH	N	N		6.5-9				1976 RB
PHENOL	Y	N	*10,200.	*2,560.	3.5mg			1980 FR
PHOSPHORUS ELEMENTAL	N	N						1976 RB
PHTHALATE ESTERS	Y	N	*940.	*3.				1980 FR
POLYNUCLEAR AROMATIC HYDROCARBONS	Y	Y			2.8ng**	31.1ng**		1980 FR
SELENIUM	Y	N	260.	35.	10.µg		0.01mg	1980 FR
SILVER	Y	N	4.1+	0.12	50.µg		0.05mg	1980 FR
SOLIDS DISSOLVED AND SALINITY	N	N			250.mg			1976 RB
SOLIDS SUSPENDED AND TURBIDITY	N	N	NARRATIVE STATEMENT - SEE DOCUMENT					1976 RB
SULFIDE-HYDROGEN SULFIDE	N	N		2.				1976 RB
TEMPERATURE	N	N	SPECIES DEPENDENT CRITERIA - SEE DOCUMENT					1976 RB
TETRACHLORINATED ETHANES	Y	N	*9,320					1980 FR
TETRACHLOROBENZENE 1,2,4,5	Y	N			38.µg	48.µg		1980 FR
TETRACHLOROETHANE 1,1,2,2	Y	Y		*2,400.	0.17µg**	10.7µg**		1980 FR
TETRACHLOROETHANES	Y	N	*9,320.					1980 FR
TETRACHLOROETHYLENE	Y	Y	*5,280.	*840.	0.8µg**	8.85µg**		1980 FR
TETRACHLOROPHENOL 2,3,5,6	Y	N						1980 FR
THALLIUM	Y	N	*1,400.	*40.	13.µg	48 µg		1980 FR
TOLUENE	Y	N	*17,500.		14.3mg	424.mg		1980 FR
TOXAPHENE	Y	Y	1.6	0.013	0.71ng**	0.73ng**	0.005mg	1980 FR
TRICHLORINATED ETHANES	Y	Y	*18,000.					1980 FR
TRICHLOROETHANE 1,1,1	Y	N			18.4mg	1.03g		1980 FR
TRICHLOROETHANE 1,1,2	Y	Y		*9,400.	0.6µg**	41.8µg**		1980 FR
TRICHLOROETHYLENE	Y	Y	*45,000.	*21,900.	2.7µg**	80.7µg**		1980 FR
TRICHLOROPHENOL 2,4,5	Y	N			2,600.µg			1980 FR
TRICHLOROPHENOL 2,4,6	N	Y		*970.	1.2µg**	3.6µg**		1980 FR
VINYL CHLORIDE	Y	Y			2.µg**	525.µg**		1980 FR
ZINC	Y	N	320.+	47.				1980 FR

g = grams
mg = milligrams
µg = micrograms
ng = nanograms
f = fibers

Y = YES
N = NO

+ = HARDNESS DEPENDENT CRITERIA (100 mg/L used)
* = INSUFFICIENT DATA TO DEVELOP CRITERIA. VALUE PRESENTED IS THE L.O.E.L. - LOWEST OBSERVED EFFECT LEVEL.
** = HUMAN HEALTH CRITERIA FOR CARCINOGENS REPORTED FOR THREE RISK LEVELS. VALUE PRESENTED IS THE 10-6 RISK LEVEL.

FR = FEDERAL REGISTER
RB = QUALITY CRITERIA FOR WATER, 1976 (REDBOOK)
M.C.L. = MAXIMUM CONTAMINANT LEVEL

NOTE: This chart is for general information; please use criteria documents or detailed summaries in "Quality Criteria for Water 1986" for regulatory purposes.

[1] These criteria concentration levels are identical to the drinking water standards set forth in the EPA Interim Primary Drinking Water Regulations as required by the Safe Drinking water Act. The listed values are applicable to situations in which untreated stream water is consumed by humans.

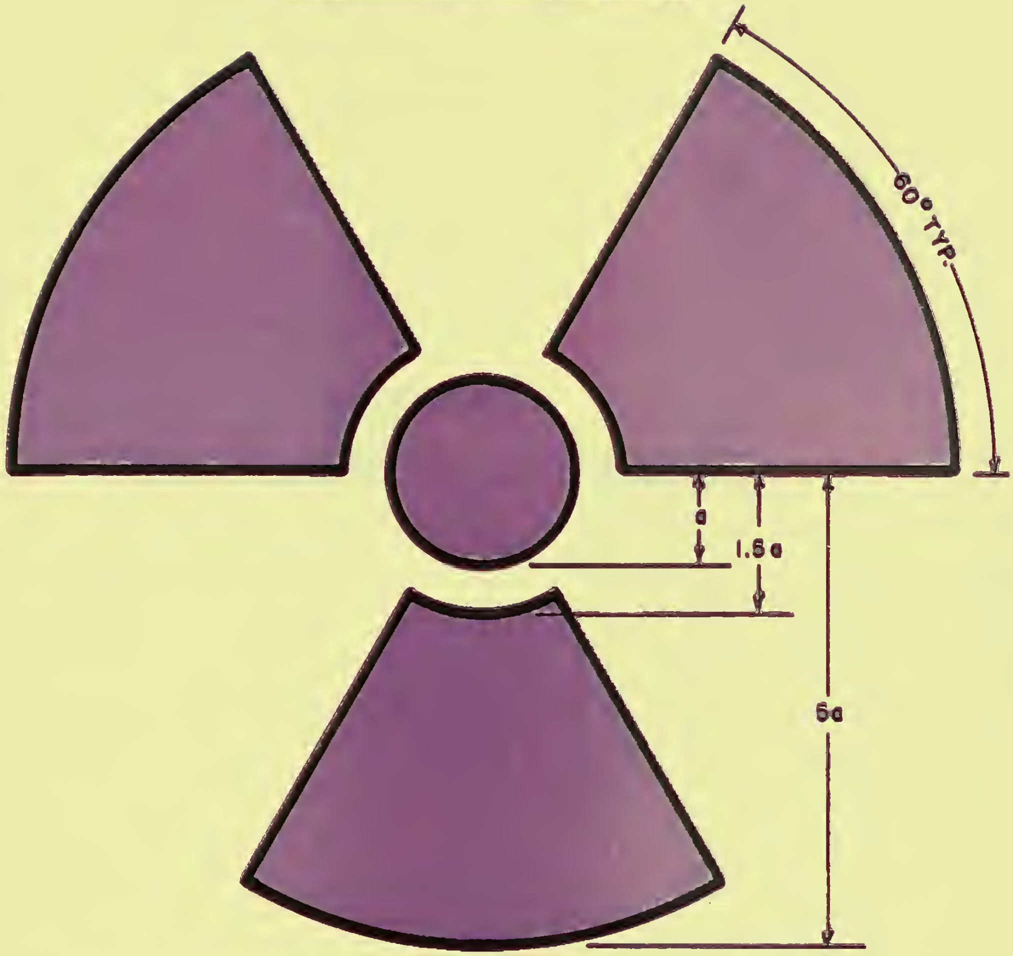
[2] The following parameters not included in this summary are also part of the interim Regulations. Their M.C.L.s are in parenthesis: fluoride *4 mg/L); turbidity (1-5 NTU); total trihalomethanes (0.1 mg/L); gross alpha (15 pci/L); and radium 226 + radium 228 (5 pci/L).

APPENDIX 4

RADIATION WARNING SIGN

The Nuclear Regulatory Commission (NRC) prescribes that radiation areas be conspicuously posted with warning signs (10 CFR §20.203). The signs should use the conventional colors of magenta or purple on a yellow background, and should display the three-bladed symbol for radiation. In addition to the words, "CAUTION (or 'DANGER'): RADIATION AREA," the sign may include any other information which would aid individuals in minimizing their exposure. The language should be direct and concise without causing undue alarm. An example suitable to the needs of Lathrop Canyon is included on the following page with dimensions included on the symbol.

CAUTION



RADIATION AREA

RADIATION LEVELS IN THIS AREA ARE ELEVATED DUE TO URANIUM MINING. A MAXIMUM OF ONE DAY SHOULD BE SPENT IN THE AREA. WATER IN THE VICINITY IS HIGHLY CONTAMINATED AND SHOULD NOT BE INGESTED.

NO CAMPING

DO NOT DRINK THE WATER

APPENDIX 4

CABLE NET CLOSURE: COST ESTIMATE

CABLE NET CLOSURES: COST ESTIMATE

This estimate was prepared by the DEVA Mine Safing Crew in response to the following memorandum from Larry Thomas, CANY Chief of Resource Management. In the memo Mr. Thomas targets 9 of the 11 major openings for closure. The estimate assumes the use of a Punjar drill or access by truck with an air compressor and GD-83 rock drill. No helicopter support should be necessary.

OPENING	# NETS	# BOLTS	COST (NETS + BOLTS)	TOTAL COST
1	1	7	$ 250 + 42	$ 292
2	3	14	750 + 84	834
3	2	10	500 + 60	560
4	3	14	750 + 84	834
5	1	7	250 + 42	292
6	3	14	750 + 84	834
7	2	10	500 + 60	560
8	1	7	250 + 42	292
9	3	14	750 + 84	834
cable sleeves	-	-	-	100
Total materials	19	97	4750 + 582	5432
Total labor	-	-	-	6000
Per diem	-	-	-	1000
GRAND TOTAL				$12,432

UNITED STATES GOVERNMENT

memorandum

DATE: June 17, 1988

REPLY TO ATTN OF: Larry Thomas

SUBJECT: Lathrop Canyon Mines

TO: Jim Woods - MMB

The openings to the mines in Lathrop Canyon are;

78 inches wide	x	85 inches high.
136		114
97		120
156		97
91		85
192		82
102		79
72		90
150		95
119 average		94 average

Radon testing has not been done in these mines but some other environmental testing was conducted in 1985. The results are attached.

Because Lathrop Canyon was being considered for nomination to the National Register of Historic Places I notified Regional Historian Mike Scheene of the proposed action. We want to be sure not to take adverse action on a culturally significant property.

One option we would like to keep open in light of the National Register nomination is the use of steel nets to close the adits. I am sure you are familiar with the work Death Valley has done with nets. Ron Cron in Death Valley gave me a very rough estimate of $9,500 to purchase and install nets over the nine mines listed above. $5,500 is for supplies which could be easily obligated this fiscal year. Doing the work this fiscal year may be difficult.

A resource to consider, although it may be expensive, is the Nevada Test Site. EG&G has a division which specializes in radioactivity. They may be able to accurately access the scope of our problem in both the mines and tailings. Ms. Holly Berry at the EGG Remote Sensing office in Las Vegas would be the person to talk to. I believe her phone number is 702-739-0511.

Larry

OPTIONAL FORM NO. 10
(REV. 1-80)
GSA FPMR (41 CFR) 101-11.6
5010-114
☆U.S. G.P.O. 1983-381-526/8309